The FOUNDRY

Volume 49
Number 12

Published
Semimonthly

CLEVELAND, OHIO, JUNE 15, 1921

From the Foundry to the Speedway

Castings for Motorcycle Frames Are Designed To Give Great Strength with Resilience—Malleable Parts Used Are Braised to Steel Tubing With Uniform Success

BY HERBERT R. SIMONDS

MOTORCYCLES call for many special castings in frame construction which must meet unusual requirements. The manufacture of these castings involves problems not only for the patternmaker but for the molder and the metallurgist as well. In the frame construction of the Indian motorcycle, made by the Hendee Mfg. Co., Springfield, Mass., malleable castings are used almost exclusively. In Fig. 2, all of the castings shown with the exception of the two fork castings at the rear are malleable, and all of these castings must meet the conditions necessary to insure proper braising to the steel tubes of the frame.

The lower central casting in Fig. 2, known as the hanger bracket is the most difficult part on the frame from a molder's view point and for this reason will be taken as an example in following through many operations which finally result in the production of one of the most important links in a machine designed for service such as is shown in Fig. 1. To give some idea of the problems met in the production of this particular casting, the sequence of operations will be followed through chronologically from start to finish.

The pattern design is somewhat unusual, because of the irregular shape of the casting itself. The pattern is shown in Fig. 3 which may be better understood by comparison with the casting itself in Fig. 5. The entire central portion along the axis line of the two fork arms is designed to be cored out. Two projecting pieces on the near side of the pattern are indicated at *A*,*A*. These pieces are held securely by nails. They are loose pieces which cannot be drawn with the pattern itself, and which therefore are dovetailed to the main pattern, so that they slide freely and remain in the mold after the pattern itself has been withdrawn. Both the cope and the drag of the mold are shown in Fig. 6. The molder in this view is shown just after he has taken out the small loose piece leaving the mold ready to receive the cores. The cores are shown in Fig. 8, and are shown in place in the drag in Fig. 7. These two cores are separated from each other the thickness of the metal wall of the casting, so that they, in effect, form the complete mold for certain parts of the casting.

The core boxes are shown in Fig. 9. Perhaps the chief feature of the casting here considered is its peculiar design which makes the pattern and core construction somewhat unusual. The core boxes shown in Fig. 9 have in themselves some problems of molding. The central box which produces the core shown at *C* in Fig. 8 could not be constructed in the usual way having the two parts separate on a flat axis, because of the over-hang which would result. It was necessary, therefore, to divide it, as shown, and even in this case, a small loose piece had to be used on the central line to take care of a projection on the casting. The loose piece is shown in the box at the extreme left at *B*, Fig. 9. It is designed to fit into the groove shown in the upper portion of the center box. Because of the odd shape of the casting, and its varying thickness of met-

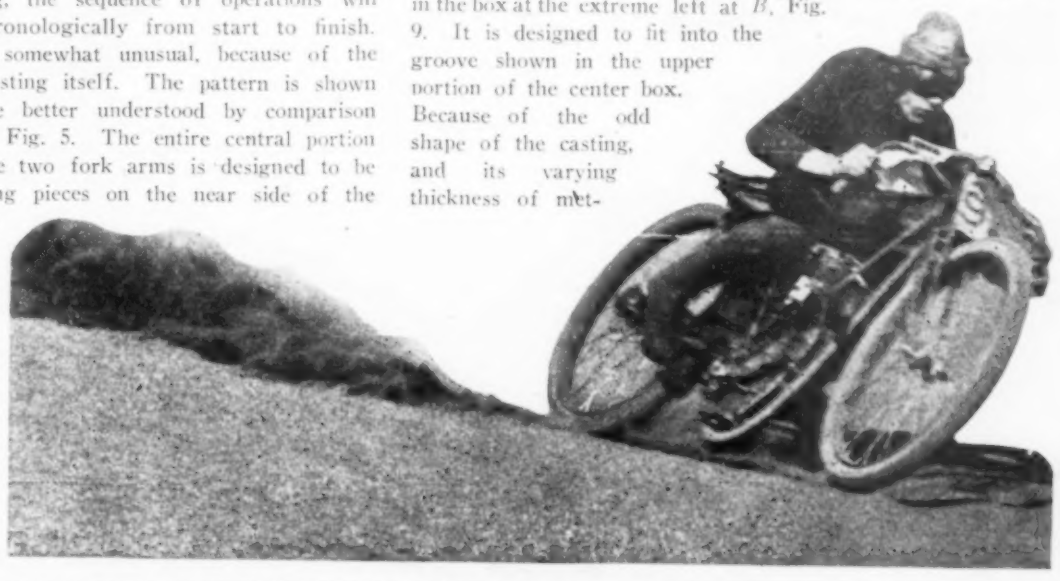


FIG. 1—FAULTY CONSTRUCTION OF CASTINGS UNDER SUCH TESTS AS THESE MIGHT CAUSE A SERIOUS ACCIDENT

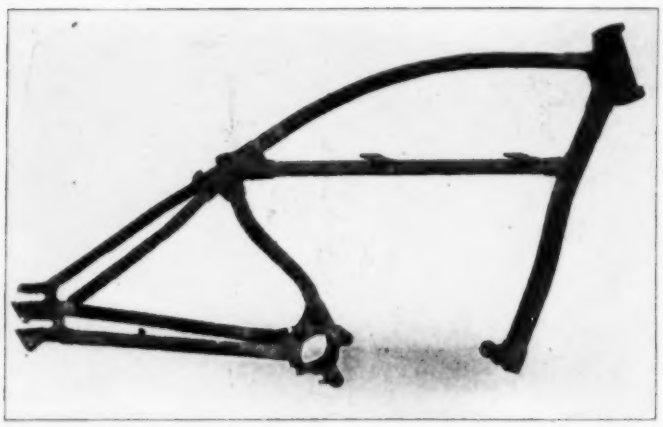


FIG. 2—THE MOTOR CYCLE FRAME JUST AFTER THE BRAISING OPERATIONS HAVE BEEN COMPLETED—THE LOWER CENTRAL CASTING IS THE HANGER BRACKET—FIG. 3—THE CASTING JUST AFTER BEING BRAISED—THE NEXT OPERATION IS TO SAW THROUGH THE RIM OF THE CENTER OPENING JUST BELOW THE FORK

al, the problem of molding has been exceedingly difficult. To get the proper flow of metal, it was found necessary to get it to the mold as hot as possible. During the early trials shrinkage cracks developed in various parts of the castings, and these had to be chased down one after another and eliminated. Sometimes, after the crack in one part had been overcome, the method used in eliminating it would create a crack in another part. The use of risers, and chill pieces constituted the chief means of combating these shrinkage cracks, but close co-operation with the metallurgist was also found necessary.

FIG. 4—THE PATTERN HAS TWO LOOSE PIECES AND UNUSUAL CORE CONSTRUCTION

At present, the mold is made up with steel chill pieces in certain places.

The gate is shown in Figs. 6 and 7, and while not unusual in foundry practice, is of a design well suited to the work in hand, and a few details may therefore be of value. A cup gate receives the hot metal at the top and at one side of the cope. The overflow from the cup drops down through a slanting hole which has a tendency to force the metal into an enlarged dead end used for the purpose of collecting impurities. The flow of the metal into the mold itself is through a quarter inch opening cut into the under surface of the cope to a point on the casting just at the base of the fork. The point where this gate has been cut off is clearly shown in Fig. 5, at *D*. In pouring, a heavy weight is used to keep the two halves of the flask together. The metal is run in as hot as possible, and is maintained as close to the following analyses as is possible:

Silicon,	0.90	to	1.00.
Manganese,			0.30.
Sulphur,			0.05.
Carbon,	2.60	to	2.70.
Phosphorus,			0.16.

After cooling, the casting is cleaned, inspected, and then carefully packed in an annealing pot for the annealing operation. To avoid warping of these irregular shaped castings, it is necessary that they be carefully and firmly packed. The space around and between them is filled with red hematite. The pots when filled are shaken and hammered, until the contents becomes a firm almost solid mass. During annealing, the heat is gradually brought up through a period of 36 hours to the maximum temperature which is held uniform for

Experience Teaches

IN ANY foundry operation individual development of ideas and methods on complicated work is necessary. It is impossible to tell accurately just where the shrinkage effects will be most pronounced in certain odd shaped castings, but the experienced molder knows that if a shrinkage occurs in one place he may do one of several things to overcome it. The most common corrective measure is the use of risers which by keeping a mass of hot metal close to a thin section of a casting counteract the effect of the hot metal bodies in heavier sections of the casting itself. The use of chills is another method of overcoming shrinkage and in the casting here described, chills placed at different points on the interior surface of the mold constituted the chief means of overcoming cracks. The method of experimentation followed was to make a casting as carefully as possible with careful gating, proper composition and temperature of metal and then to examine for cracks. When a crack developed a chill was placed at that point and another casting made under the changed conditions. At first the placing of these chills merely drove the shrinkage crack from one point to another, but proper experimenting in the location and size of chills finally overcame the effects of shrinkage.

FIG. 5—THE CHIEF DIFFICULTIES IN PRODUCING THESE CASTINGS WERE THE SHRINKAGE CRACKS IN CASTING AND THE WARPING OF THE FORK ARMS IN ANNEALING

FIG. 6—AFTER DRAWING OUT THE MAIN PARTS OF THE PATTERN, THE SMALL LOOSE PIECES ARE CAREFULLY REMOVED FROM THE SAND FIG. 7—AFTER REMOVING THE PATTERN, THE CORES ARE ACCURATELY PLACED, AND A FLASK IS THEN READY TO CLOSE

about five days. The castings are then allowed to cool gradually through another period of 36 hours. After the castings have been removed from the furnace, and from the pots, they are taken to the cleaning room for a final cleaning operation and then are again finally inspected and sent to the shipping room.

The Hendee Manufacturing Co. at Springfield does not operate a foundry and it is therefore necessary to have these malleable castings made elsewhere and shipped in. The casting described here is made at the plant of the Arcade Malleable Iron Co., Worcester, Mass. When the castings reach the Springfield plant they are first roughly checked as to dimension. The main central opening is then bored, and the casting placed on a special chuck attachment as shown in Fig. 10, which brings the end of one fork on the center line of the lathe. A center point brought up to this fork end enables the operator to judge whether the cut as shown in the illustration, can be made with a reasonable uniform thickness of metal wall left. If the position of this fork end is not sufficiently accurate, it is necessary to take the casting off and through the use of a special appliance bend the two forks to the correct position. These forks are sometimes bent as much as 1/8 inch and are expected to stand at least a 1/16 inch bend without any signs of cracking or injury. This gives some idea of the requirements placed on these malleable castings. After the fork ends are turned down the casting is placed in a special jig as shown in Fig. 11 and all holes are drilled.

The next operation is that of braising the casting on to the frame tubes as shown in Fig. 4. This view shows the castings just after the braising operation has been completed and before the joints have been ground down. In braising, it is necessary to bring the entire casting to almost 1900 degrees Fahr., and in the early stages of development of this casting, the loss due to cracking under the heat developed in this braising operation was extensive. It was found necessary to obtain a solid braised connection to heat the casting above 1600 degrees and preferably over 1800 degrees Fahr. The most remarkable feature of these castings is their ability to withstand this high temperature without losing their malleable properties. In aligning the frame after it is completed, it often is necessary to make silght adjustments and castings which are not malleable will crack under this adjustment. In this case the entire frame must be discarded.

At first, the company used a brais-

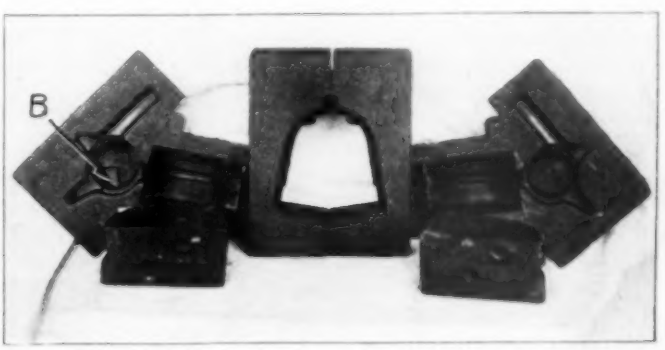


FIG. 8—A CORE AT THE RIGHT FITS BETWEEN THE FORKED ARMS OF THE CORE AT THE LEFT, SO THAT METAL FLOWING BETWEEN THE TWO, FORMS PART OF THE CASTING FIG. 9—THE CORE BOXES ARE SOMEWHAT UNUSUAL IN DESIGN—THE CENTER BOX HAS A LOOSE PIECE SHOWN INSIDE THE LEFT HAND BOX

ing wire of lower melting temperature. Through experiment it was found that improved properties were obtained by the use of a high temperature wire and accordingly castings were sought which would withstand this high temperature without losing their ability to withstand the stresses arising under final adjustment. The losses averaged over 50 per cent, but with the castings made specially by the Arcade Co., it was found possible to carry on the braising operation as desired with a much lower loss. With temperatures ranging close to 1900 degrees, many of these castings were put through tests which conclusively proved the retention of malleable properties. Sawed sections show a dark center even in the thin portions of the castings.

When braising is completed a radial cut is made through the wall of the large opening so as to give a slight springiness to this opening and a means of clamping the bearing which it supports. In Fig. 4, the small drill holes shown penetrating the base of the fork are for taking bolts which extend across the sawed slot and furnish the means of clamping. At first, this slot was cut before the braising operation was performed, but warping was found to be so severe that the present practice of sawing the slot after braising, was adopted and has proved satisfactory.

The hanger bracket supports the bearing which carries the two intermediate drive sprockets of the motorcycle, one driven from the engine, and the other driving the rear wheel. The test which these castings often receive is illustrated in Fig. 1.

This briefly is the history of one particular piece from the metal to the complete part in a motorcycle. The production of the other castings entering into the full assembly involves many other problems, each of which has been met and overcome through experiment and care.

Castings for the automotive industry are all subjected to shock in addition to the usual strains, and perhaps in a motorcycle this factor is more pronounced than in any other machine. In the construction of the frame here considered, the use of malleable castings is an interesting development. It is unusual to braise tubing to castings because the heat required for braising so nearly approaches the melting point of the castings. The hanger bracket here considered must combine accuracy with sufficient pliability to permit alignment when the machine is assembled. The inspection is rigid and at first the rejections were exceedingly high. Now the practice has been perfected in so many details that rejections are but little higher than for castings destined for more usual work. Rejections by the Hendee Co. at the present time on the hanger brackets after they have been received at the plant amount to less than 10 per cent. Rejections at the foundry are somewhat less, making the total rejections from metal to completed castings about 16 to 18 per cent. During the development of this casting, different analyses of iron and different methods of gating were tried out and those here described are the result.

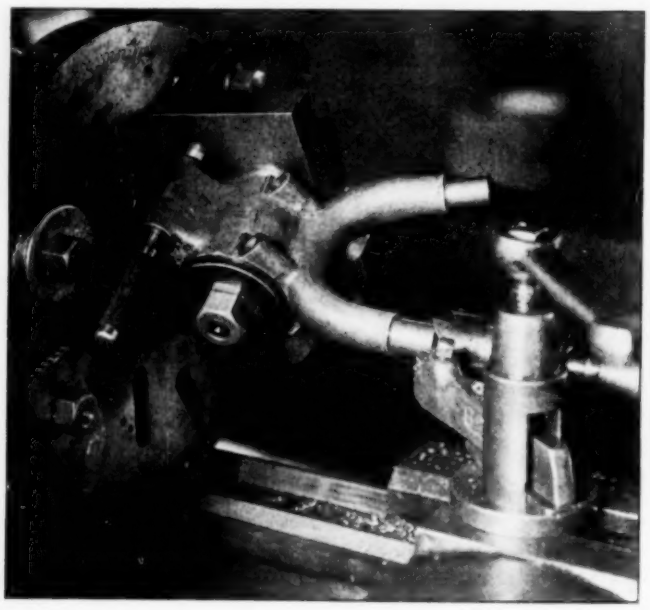


FIG. 10—IN FINISHING THE ENDS OF THE FORK TO RECEIVE THE TUBING, THE THICKNESS OF WALL LEFT MUST BE UNIFORM—THIS OFTEN NECESSITATES BENDING THE FORK

The first coke iron produced in America was made at Bear furnace, Armstrong county, Pa., 86 years after the introduction of coke in England. The first experiment in America with the use of bituminous coal was also made at Bear furnace the same year but was unsuccessful.

Zinc Output Increases

How Oklahoma and Kansas zinc ore production is growing, while nearly all other districts are going backward is well shown in figures recently compiled by the United States geological survey. Montana, which began its spectacular growth a few years before Oklahoma, as a miner of zinc ore, is holding its own at a high level and second place among the states having only two records above 1920, and they were only slightly above.

Missouri, however, has less than 25,000 tons of recoverable content from its ore shipped last year, compared with first place among the states until 1918, when it fell from well over 100,000 tons to about 56,000. In that year Oklahoma doubled its output, from 85,000 in 1917 to 161,000 in 1918, and last year at over 200,000 was about 10 times as heavy a producer as in prewar days. Kansas also made its peak in 1920.

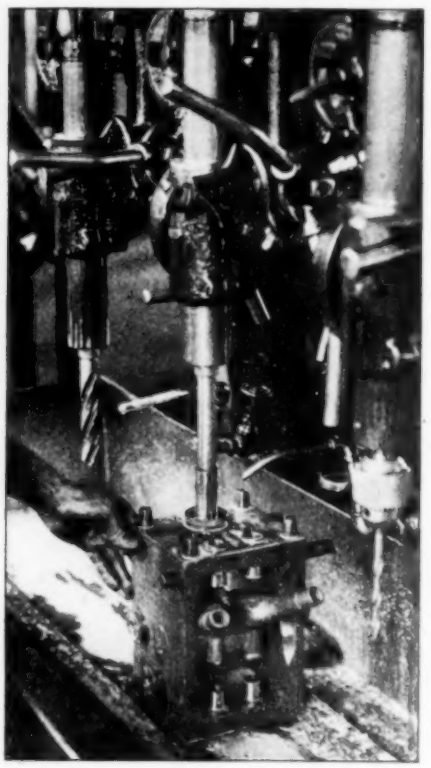


FIG. 11—THE CASTING IS PLACED INTO A RATHER COMPLICATED JIG BOX WHICH INSURES ACCURACY IN THE DRILLING OF ALL HOLES

New Jersey has fallen considerably in the past few years to about the level that prevailed before the war. Wisconsin, after a substantial growth to as high as nearly 60,000 tons in the war period, has fallen to slightly less than its prewar years. The Joplin district more clearly than ever was the dominant factor in production, with over half.

Reviews British Pyrometry Practice

Descriptions Are Given of the Construction and Applications of the Older Forms of Pyrometers as Well as of the More Widely Used Electrical and Optical Instruments

BY ERNEST J. DAVIS

THE application of pyrometers to industrial temperature measurements has passed through a process of evolution similar to that of many other mechanical appliances. Whereas a pyrometer was formerly regarded as a luxury and frequently purchased with little understanding of its uses, capabilities or limitations and kept stowed away in the office to be used only on state occasions, it is now becoming a real live tool in the hands of the foundryman and the metallurgist working with high temperature.

Before the advent of pyrometers, the criterion of heat treatment operations was the skill of the operator. Although it is not suggested that the skill and judgment of the operator is not important, it is becoming more essential that a scheme when laid down can be followed by semiskilled operators, and it is in enabling this accomplishment that the application of the pyrometer produces the most valuable results.

Numerous instruments for measuring temperaure, utilizing almost every known thermal phenomenon, from time to time have been placed upon the market. But the number of instruments that find any industrial application is limited by their practicability, and particularly their ability to withstand rough usage. The ordinary mercury thermometer is of little use in the foundry on account of its restricted range (mercury boiling at 356 degrees Cent. under atmospheric pressure) and its lack of robustness. Glass thermometers have been made by which temperatures higher than 350 degrees Cent. can be measured, by introducing nitrogen under pressure above the mercury, but the rough usage to which they would be subjected in the foundry preclude their use in this industry.

One of the simplest means of obtaining an approximate measurement of the temperatures is to make use of the principle of fusion, for instance, the insertion of a fragment of metal of known melting point into the furnace whose temperature is to be tested will often give at once the required information. Thus the temperature for tempering steel tools may be controlled by the insertion in the bath of thin rods of tin, lead or zinc, the melting points of which are 232, 327 and 419 degrees Cent. respectively. This method though very crude can be made useful and has been greatly improved by Dr. H. Seger who devised and manufactured a series of mixtures which are commonly known as Seger cones. These cones consist of truncated pyramidal-shaped bodies composed of graduated mixtures of aluminum silicates which soften and fuse at definite temperatures and by the aid of which it is possible to determine the approximate temperature of furnaces and heated spaces. Cones are supplied for every 50 degrees Cent. rise in temperature from 600 degrees Cent. to 1850 degrees Cent. By the use of these cones an indication of temperature may be obtained. In practice a number of cones are placed in the furnace ranging over perhaps 5 or 6 numbers in sequence, and allowed to gain the temperature of the furnace. It will then be found that some of the cones have completely collapsed, while others are hardly altered. The temperature is taken to be that at which a particular cone in the series appears to present a mean degree of fusion. This method of temperature control is used largely in the pottery industry.

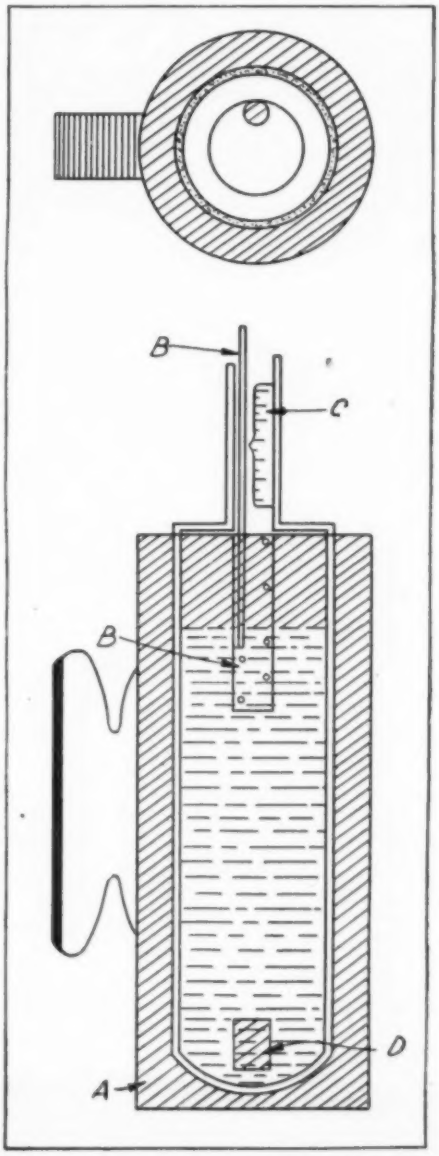


FIG. 1—SIEMENS WATER PYROMETER

The Siemens water pyrometer, one of the earliest instruments for measurements of temperature, found considerable favor some years ago and is still in use in a number of works today. The apparatus consists of a cylindrical copper vessel provided with a handle and containing a smaller copper vessel. An air space separates the vessels and the inner one is surrounded by a layer of felt in order to retard loss of temperature. The capacity of the inner vessel is a little over one pint. A mercury thermometer, *B*, Fig 1, is fixed close to the wall of the inner vessel, its lower end being protected by a perforated brass tube, while the upper part projects above the vessel. At the side of the thermometer is a small brass scale, *C*, which is made to slip up and down. On a level with the zero division of the brass scale a small point is fastened which traverses the scale of the thermometer. Small cylinders, *D*, Fig. 1, of either nickel, copper or iron and sometimes platinum which are so adjusted that their heat capacity at ordinary temperatures is equal to 1/50 that of the copper vessel containing 1 pint of water, are used. However, as the specific heat increases with the temperature, allowance is made on the scale, *C*, which is divided according to the metal cylinder used.

A determination is carried out as follows: Exactly 1 pint of clean water is placed in the inner copper vessel and allowed to stand for some time to

allow the temperature to become steady. The brass scale, *C*, is then set with its index opposite the temperature of the water as read on the thermometer. Meanwhile one of the metal cylinders is exposed to the temperature to be measured and after allowing it to obtain that temperature uniformly, it is rapidly withdrawn and carefully dipped into the pyrometer vessel. The temperature of the water then rises and when the thermometer has become stationary the reading is taken and at the same time the reading on the scale *C* opposite to the top of the mercury column is noted. The sum of these two values gives the temperature of the heated space in which the metal cylinders were placed. With cylinders of iron or copper temperatures up to 1000 degrees Cent. can be measured. For higher temperatures cylinders of nickel or platinum are used.

A new era in the measurement of heat began with the work of Sir William Siemens, who showed that electrical resistance might be used for measuring temperature. The principle on which resistance pyrometers operate is that the electrical resistance of metals changes with rise of temperature. The platinum resistance pyrometer consists of a coil of fine platinum wire wound on a mica frame and protected from injurious gases by a glazed porcelain tube. A divided current passes from a battery to the platinum coil and to a resistance. At the ordinary temperature the resistance of the platinum coil is just balanced by the standard resistance and an equal current will flow through each. If, however, the coil be heated, its resistance will be increased, this increase can be measured and thus gives an indication of the temperature. Fig. 2, is a diagrammatic sketch of a platinum resistance pyrometer with connections. *AB* and *BC* are equal resistances, forming the arms of the balance. The battery (not shown) is connected at *A* and *C*, and one terminal of the galvanometer *G* is connected *at B*. *DE* represents a set of resistance coils, which together with the resistance, *AB* and *BC* may be replaced by a box of coils. *FK* represents a straight bridge wire with a divided scale attached. The contact piece *H*, which slides along the bridge wire is connected to the second terminal of the galvanometer. The leads *AM* and *KN* from the pyrometer coil *P* are connected to *A* and *K*. The compensating leads, *CL* and *LD*, the resistance of which just balance the resistances *AM* and *KN*, are connected to *C* and *D*. These four leads may be of any convenient length, and are symmetrically arranged so that corresponding parts are always at the same temperature. When the balance is found by inserting suitable resistances in the arm *DE* and sliding the contact piece *H*, it is obvious that since the resistances *AB* and *BC* are equal, the resistance of the pyrometer and its leads together with that of the length *HK* of the bridge wire will be equal to the remaining portion *FH* of the bridge wire together with the coils *DE* and the compensation *CLD*. Thus the changes of resistance of pyrometer leads *AM* and *KN* are compensated by equal changes in the leads, *CL* and *LD* and the resistance of the coil *P* is directly given by the sum of the coils *DE* and the reading of the bridge wire scale. The resistance of a centimeter of the bridge wire is made to correspond to an increase of resistance in the coil *P* as would be produced by a rise of 1 degree Cent. in temperature. The galvanometer can easily be made sensitive to 1-100 of a centimeter of this bridge wire. For reading temperatures direct by this pyrometer, the whipple temperature indicator is often used, but the pyrometer is suitable for continuous temperature measurement and is used in this connection with a recording instrument such as the Callender recorder or the thread recorder whereby records of temperature can be obtained over a period of 2 hours, 12 hours or 24 hours.

Resistance Pyrometer Delicate

The resistance pyrometer is an excellent instrument for measuring temperatures below 1000 degrees Cent., but for higher temperature it is not suitable or reliable. It is more useful as an instrument of reference of standard pyrometer, as it is hardly robust enough for general works use and the recording apparatus is rather delicate.

By far the most useful pyrometer is that of the thermocouple type. This is constructed upon the well known phenomena that if a junction is made between two wires of dissimilar metals or alloys a difference of potential will be set up between the two free ends of the wire if the junction is heated and the free ends maintained at normal temperature. The difference in potential thus produced gives a means of estimating the temperature of the junction and incidentally that of the body with which the junction is in contact. The use of this means of measuring temperature appears to have been suggested by A. C. Becqueral in 1826 and adopted by Pouillet some years later. Unfortunately at first the metals comprising the wires that formed the thermo-junction were badly chosen and the use of this type pyrometer was consequently greatly retarded until in 1887 Le Chatelier advocated the use of pure platinum in conjunction with an alloy of platinum and rhodium or iridium. This thermo-couple has been shown to give trustworthy temperature readings and can be used for temperatures up to about 1100 degrees Cent., but owing to the high price of the metals composing it, its use is restricted. With the introduction of base metal thermocouples a cheap, robust and convenient instrument for measuring temperatures was obtained. The base metal couple is usually composed of wires of an alloy of nickel and chromium insulated from each other by means of fireclay tubes. To make a junction the ends may be simply twisted together or used by means of the oxyhydrogen flame. The latter method is much to be preferred. The wires are then connected with a dead-beat galvanometer, the suspended coil type being particularly suitable. The galvanometer may be used either as direct reading or to give a continuous record. The pyrometer is calibrated by exposing the junction to a series of known temperatures such as the soliditying points of pure metals and salts There is no difficulty in recognizing the melting or solidifying point of a pure metal, for, as the mass passes from the solid to the liquid state or vice versa the temperature remains constant for a brief period. The duration of this transitional period depends on the amount of material operated upon and its latent heat of fusion. When the pointer of the galvanometer remains stationary for a brief period the solidifying temperature under estimation is indicated. The following list gives the substances usually used for calibrating thermocouples:

	Degrees Cent.
Ice	0
Boiling water	100
Melting point of tin	232
Melting point of lead	327
Melting point of zinc	419
Boiling point of sulphur	444
Melting point of aluminum	657
Melting point of copper	1084

The details of the method to be adopted in using the thermo-electric pyrometer of this type will vary according to the use to which the pyrometer is put. In the first place the choice of couple will depend upon the range of temperature to be measured, for temperatures up to 500 degrees Cent. a copper-constantan couple is suitable; for temperatures of from 900 to 1000 degrees Cent. and over a couple of platinum-platinum iridium wires is required, while within the last few years base metal couples have been used to measure temperatures up

to 900 or even 1000 degrees Cent. In one base metal couple an alloy of 90 per cent nickel and 10 per cent chromium is used for one wire and the second wire is composed of 98 per cent nickel and 2 per cent aluminum.

It is necessary for extreme accuracy to have the cold junction kept at a uniform temperature. To insure this the cold junction should be as far away from the source of heat as possible and special arrangements must be made to keep the temperature uniform. In the base metal couple, trouble with the cold junction is eliminated by having the leads connecting the couple and galvanometer of the same

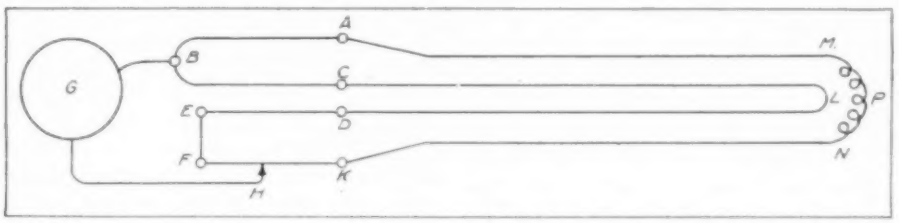


FIG. 2—DIAGRAMATIC SKETCH OF A PLATINUM RESISTANCE PYROMETER WITH ITS CONNECTIONS

wire as the couple. Thus the cold junction is directly connected to the galvanometer where the temperature is comparativey constant.

One of the important features of the thermocouple is its small size. When suitably protected it may be inserted in the molten metal for measuring the temperature. This type of pyrometer is particularly useful in the nonferrous foundry where with suitable protection, the pouring temperatures can be readily obtained. Considerable trouble is experienced by the corrosive action of the phosphor bronzes, the usual iron tube of the pyrometer being rapidly eaten away when the couple is inserted in a bath of this character. It is possible in some cases to use the couple for short periods protected only by asbestos string.

Air Thermometers Have Uses

For very accurate temperature measurements in scientific research the modification of the air thermometer devised by Deville and Troost is generally used, but the apparatus is much too cumbersome and delicate to be used industrially. Several forms of pneumatic pyrometers have been designed for industrial use. Of these the Uhling pyrometer is probably the best known. The Uhling pyrometer finds a large application in iron and steel works particularly for taking the temperature of the hot blast. This pyrometer is based upon the laws governing the flow of air through small apertures. Its principle is illustrated in the diagrammatic drawings, Fig. 5. The chamber C has an inlet aperture A and an outlet aperture B. A uniform suction is created in the chamber C^1 by the the steam aspirator D. Air will be drawn into the chamber C^1 creating a suction in C which in turn causes air to enter through A. The velocity at which it flows through B depends upon the suction in C, and the velocity at which it flows through B depends upon the excess suction in C^1 over that in the chamber C.

As the suction in C increases, the effective suction in C^1 must decrease and hence the velocity at which air flows through A increases and the velocity at which air flows through B decreases until the velocity of flow through both apertures becomes equal. When this occurs no further change of suction in C will take place. Air is expanded by heat and the higher the temperature the greater will be its volume and the smaller will be the quantity drawn through a given aperture by the same suction after it has again been reduced to normal temperature. If, therefore, the atmospheric air before entering A is heated and again cooled to some lower temperature, say 100 degrees Cent., before passing through B less air will enter through A than is drawn out through B, hence the suction in C must increase and the effective suction in C^1 decrease. Therefore the velocity of air through A will increase and that through B will decrease until again the same quantity of air flows through the aperture. Thus every change in temperature of the air entering through A will cause a corresponding change in the suction in C and these changes in suction will truly represent changes in temperature of the air entering through A. Two monometer tubes P and Q communicate respectively with C and C^1 the lower ends being immersed in water. The column in P will indicate suction in C^1. For successful working a perfectly uniform suction is required and the chambers must be totally airtight, also the aperture B must be of a uniform and constant temperature. The actual construction of the pyrometer is more complicated than Fig. 3 indicates, but the foregoing description will serve to illustrate the principle. A recording gage is supplied with the instrument, the changes in suction being drawn automatically on a sheet of paper. The pyrometer is reliable up to 1400 degrees Cent. and the recorder, though accurate, is durable and is little effected by vibrations.

Advantages of Radiation Pyrometer

The methods of temperature measurement so far described are all more or less limited in their usefulness by the fact that the component parts are unstable at high temperatures. The thermo-electric couple is very convenient for industrial use, but it is limited by its range. However, if the thermo-junction is kept outside the furnace away from the source of heat it would be possible to measure much higher temperatures and the life of the couple would be considerably prolonged. Advantage has been taken of this principle in constructing a pyrometer known as the Fery radiation pyrometer. The working of this pyrometer is based on the laws of radiation. It is so constructed that it can be placed at some distance from the furnace and no part of it is raised about 90 to 100 degrees Cent. In this type of instrument the radiations which emanate

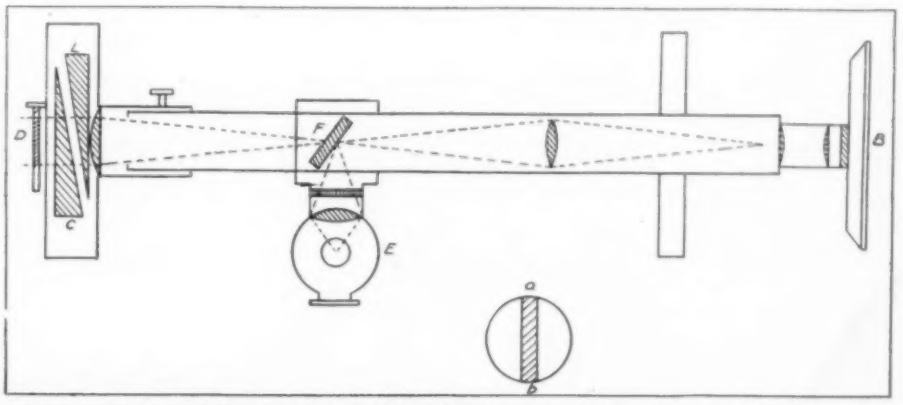


FIG. 3—IMPROVED FORM OF OPTICAL PYROMETER DEVELOPED FROM THE ONE ORIGINATED BY LE CHATELIER, WHICH WAS ONE OF THE EARLIEST FORMS OF THIS TYPE PYROMETER

from a hot body, or which pass out through an observation hole in the wall of a furnace, fall upon a concave mirror and are thus brought to a focus. In this focus is placed a junction of a thermocouple whose temperature is raised by the radiations falling upon it. This produces an electromotive force which increases as the temperature of the furnace rises, and is read off on a galvanometer, or a continuous record may be taken. The couple is of the copper-constantan type and is placed on the optical axis of the telescope, Fig. 4, and arranged in the form of a cross. An observation hole is necessary in the furnace, which is sighted through the eye-piece *O* and the image of this hole is brought into coincidence with that of the thermocouple. It is necessary that the image of the observation hole should slightly overlap the junction which appears to the eye as a black disk in the center of the field of view. The readings of the instrument are then independent of the size of the observation hole. The image of the hole is reflected to the eye-piece *O* by two small mirrors placed close to the couple. These mirrors serve for the adjustment of focus. They are so arranged that the image of the hole appears to be in two parts which only coincide when the focusing is correct. The radiations thus focussed upon the junction produce a rise in temperature which has been shown experimentally to be proportional to the amount of ardiant energy which enters the telescope. Temperatures as low as 600 degrees Cent. can be measured with this pyrometer but it is more suitable for high temperatures. This pyrometer is particularly useful where portability is required as the pyrometer can be moved from furnace to furnace with little loss of time in setting up.

A number of types of optical pyrometers in which the estimation of temperature by the oldest form of pyrometer—the eye—is made quantitative have been designed. All these instruments utilize the same principle, which depends upon the well known law, determining the relationship of the rays of light to the heat emitted by an incandescent body. One of the earliest forms of optical pyrometers was that of Le Chatelier of which the Fery absorption pyrometer, Fig. 3, is an improved form. This pyrometer consists of a telescope *DB* which carries a small comparison lamp *E* attached laterally. The image of the flame of the lamp *E* is projected onto a mirror, *F*, placed at an angle of 45 degrees. The mirror is silvered only over a narrow vertical strip *ab*. The telescope is focused on the object the temperature of which it is desired to measure; the object being viewed on either side of the silvered strip. A pair of absorbing-glass wedges *L* and *C* are placed in front of the objective of the telescope. These wedges are moved laterally by means of a micrometer screw until the light from the object under observation is made photometrically equal to that emitted by the standard lamp *E*. An auxiliary dark glass *D* is also fitted to enable the instrument to work over a higher range of temperature. A table is necessary in order to convert the readings obtained by the scale attached to the eye piece, into degrees centigrade. In taking a reading all that is necessary is to focus the telescope by adjusting the light emitted from the hot body to equal that of the standard lamp.

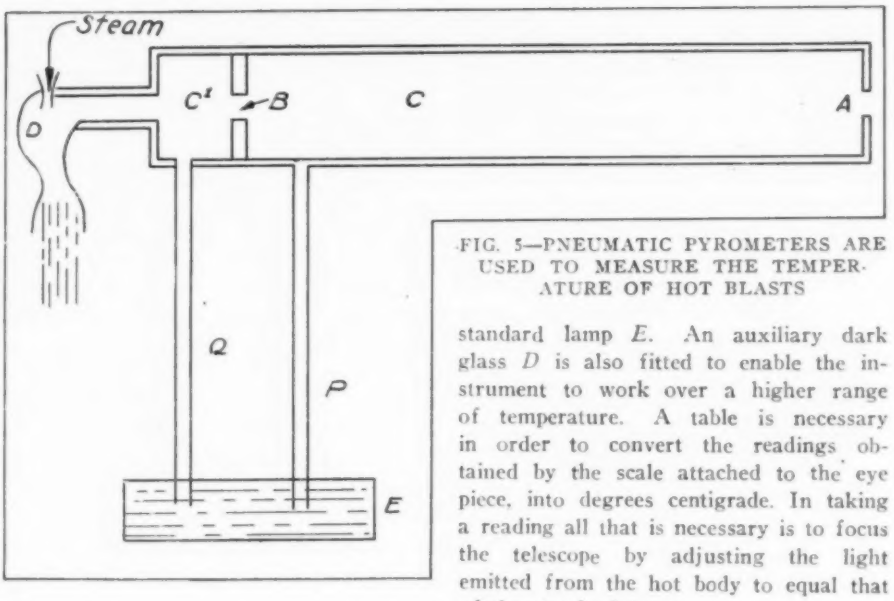


FIG. 5—PNEUMATIC PYROMETERS ARE USED TO MEASURE THE TEMPERATURE OF HOT BLASTS

The Wanner pyrometer is another pyrometer belonging to this class and has been much used in industrial works. The light from the object under observation enters the pyrometer through a slit and after traversing lenses and a prism forms a spectrum from which a small region in the red is cut off for use by means of a diaphragm. The intensity is measured by polarization. A small electric incandescent 6-volt lamp is attached to that end of the apparatus which is directed toward the light under observation and the light from this is also admitted to the apparatus and utilized for the purpose of comparison with the intensity to be measured. On looking through the eye-piece the circular field of vision is seen to be divided into two halves, one of which is illuminated by the electric lamp and the other half by the rays from the body under observation, the color being red. By inserting a rotating eye-piece containing a nicol prism the intensity of the two halves of the field of vision are easily equalized. The angle of rotation is measured on a circular scale and the corresponding temperature found from a table provided. The apparatus is made in the form of a portable telescope similar to the Fery absorption pyrometer and can be used at almost any distance from the object provided the field of vision is fairly well filled with light. It is advisable to standardize the instrument occassionally. This is accomplished by focusing onto a flame from an amyl-acetate lamp and equalizing the half circles as before, the deviation from the zero is noted and a correction made if necessary.

The application of pyrometers to any process requires careful consideration because of the special conditions which may have to be met. Numerous dif-

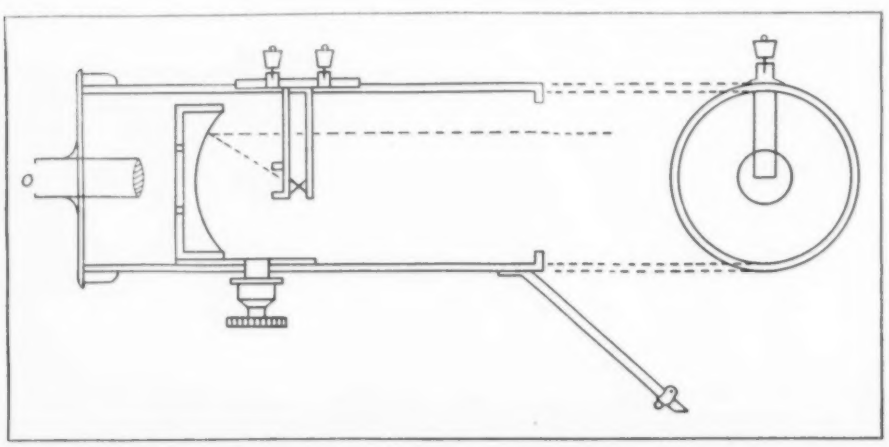


FIG. 4—THE RADIATION PYROMETER FOCUSES RADIATIONS FROM A HOT BODY ON THE JUNCTION OF A THERMOCOUPLE

ferent types of pyrometers are available. The most important of these have been described and their usefulness indicated. For foundry work careful consideration is necessary in the choice of a pyrometer and the type decided on will depend largely on the work of the particular foundry. The radiation pyrometer is suitable for high temperatures and can be focused directly upon the object whose temperature is to be measured. The temperature of molten metals and alloys have thus been controlled but the scum or dross on the surface of molten metals usually prevents the readings having more than a comparative value. This difficulty has been met by inserting a porcelain tube into the molten metal and focusing the pyrometer onto the bottom of the tube. Base metal thermocouples find considerable use in the nonferrous metal foundry and when protected by a stout iron tube and insulated with asbestos and fireclay, can be inserted into the molten metal without any injurious effects on the couple. But with alloys of the phosphor-bronze type considerable trouble is experienced. The iron sheath is rapidly attacked by this class of alloys and frequently has to be renewed. Some success has been obtained by using the bare couple, i.e., without any protecting sheath, the wires themselves being protected by asbestos string. The platinum thermocouples are not so well suited for foundry work on account of high initial costs and expensive upkeep. For general use the pyrometers that have the largest scope, are the base metal couples and the optical pyrometers, which supply the chief requirements—robustness and portability combined with reasonable accuracy.

Protecting Cores from Phosphor Bronze

In the *How and Why in Brass Founding* section of a recent issue of THE FOUNDRY a question and answer were published dealing with the penetrating action of phosphor bronze on molding and core sand. During the past two years I have had a somewhat similar experience in casting a number of pump parts weighing from 2 to 500 pounds made of that metal and the practice which I observed may be of interest to a considerable number of readers.

The impeller of a centrifugal pump on account of its intricate design must be cast with hot metal and with former core sand mixtures resulted in a mess that required hours to clean. In fact it could not be cleaned properly. With the present core sand mixture I experience no trouble, a few taps from a hammer will loosen all the sand which then runs out of the casting of its own accord. The same condition obtains with sleeves and bushings. As a general rule anything up to 100 pounds can be made satisfactorily in green sand. Beyond that weight it is advisable to make them in dry sand or to skin dry them.

For facing sand I mix 75 per cent new molding sand and 25 per cent old molding sand. This sand always is dry and afterward wet down to the ordinary molding point with clay wash. In fact I prefer to keep it a little on the dry side for green sand molds. The sand is rammed firmly and well vented and after the pattern has been removed the face of the mold is covered with a good grade of plumbago rubbed on by hand.

For cores I use a 50-50 mixture of silica sand and river sand. The sand is thoroughly dried before it is mixed and is bonded with linseed oil in the proportion of 40 to 1. A good thick coating of plumbago wash applied either when the core is green or after it has dried will insure a clean skin on the casting.

Small Cupola Is Feasible

By C. E. Lyall

On page 408 of the May 15 issue of THE FOUNDRY it is stated in answer to a question, that a cupola is not adapted to melting high grade iron for castings from 1 to 30 pounds and aggregating from 2000 to 3000 pounds a week. Further it is claimed that a small electric or oil burning furnace is the logical melting device to install under those conditions. As a practical foundryman, one who has operated small cupolas successfully for the past 9 years, on charges ranging from 50 pounds up, on gray iron, semisteel, hard white iron and also occasionally on tool steel from ⅛ to 500 pounds, I think the cupola is an ideal melting unit. It can be erected and installed cheaply, it costs little to operate and in the event that it is necessary to increase the melting capacity the blast simply is left on that much longer. For flexibility of operation it is in a class by itself.

A cupola 25 inches in diameter and 84 inches high provided with suitable tuyeres and blower can be manipulated in a surprising manner. An interesting experience in this line is described on page 245 March 15 issue of THE FOUNDRY under the title "Runs Four Heats a Day in Small Cupola."

The works of the Fremont Stove Co., Fremont, O., closed since December, 1920, have reopened with a full force of workmen.

Book Review

Metallography, Part II, by Samuel L. Hoyt, metallurgical engineer, National Lamp Works of General Electric Co., Cleveland; cloth, 462 pp., 6 x 9 inches; published by the McGraw-Hill Book Co., Inc., New York, and furnished by THE FOUNDRY, Cleveland, for $5, net.

To dispose of the metallography of steel and cast iron satisfactorily in 165 pages of ordinary book size requires a broad knowledge of the subject, careful discrimination between essentials and non-essentials and skill in weaving the abridged information into a concise yet understandable whole. Doctor Hoyt seems to have accomplished this task in Chapter V of the second volume of his work on metallography. While the treatise is not complete, and is not meant to be, it covers the important points so that the average reader may obtain a technical working knowledge of the complicated series of iron-carbon alloys. With the text of the chapter as a basis, and by consulting the carefully selected bibliography which is presented in the form of footnotes, the reader easily could explore the entire field of metallography as applied to steel and cast iron, as the references cover the work of the world's foremost metallurgists.

Chapter V is supplemented by a chapter on special steels including ternary construction steels, containing nickel, cobalt, copper, manganese, silicon and aluminum; ternary tool and cutlery steels containing chromium, tungsten, molybdenum, vanadium, etc.; and complex construction steels, such as chrome-nickel, chrome-vanadium, and complex molybdenum steels. The author has compiled the most recent data on these alloys and has devoted attention to their electrical, thermal and fatigue resisting properties. The latter part of the chapter is a valuable discussion on high-speed tool steel.

The first part of the book is devoted to chapters on pure metals, white metal alloys, light metal alloys, brasses and bronzes. The data on aluminum alloy and on bearing metals are of unusual practical value. In the case of each metal or alloy, the author touches upon the constitution and microstructure, properties, effect of different treatment and influence of impurities.

Not the least important feature of the book is the collection of excellent photomicrographs, many of which were reproduced from the files of Dr. H. Hanemann. The results of many tests on metals and alloys, presented in tabular form, enhance the value of the work as a reference book.

David D. Baxter recently has been made New York representative for Frederic B. Stevens, Detroit.

Electric Melting Nonferrous Alloys

List Given of All Installations of Electric Furnaces for Nonferrous Metals in the United States, Together with a Discussion of the Characteristics of the Different Types

BY H. W. GILLETT

FIVE years ago nonferrous electric furnaces had to be discussed with the emphasis on hopes. Today the recital of actual achievement in this field is no short story, and while the future undoubtedly holds both improvements for the furnaces now in use and the adoption for specific uses of other types than those now common, yet wide use and a fair degree of standardization has already been attained, as is shown in Table I. Experimental laboratory installations and inactive or discarded furnaces have been excluded from this table in order to avoid padding the returns.

In selecting a furnace for service in nonferrous melting three things have to be considered: The characteristics of the alloys to be melted; the characteristics of the furnace, and the nature of the work, *i. e.* the tonnage desired, the number of hours per day the furnace is to work, and whether various alloys are to be melted in the same furnace.

Table III gives data on the applicability of various furnace types to various alloys. An O. K. in this table does not necessarily mean that it is economically desirable to melt a given alloy in a given furnace—merely that it is metallurgically feasible.

Zinc Volatilized

The main important characteristics of brass from the point of view of electric melting are the volatility of the zinc contained in it and the rate of heat conduction through the molten brass. If heat is supplied from above at a more rapid rate than it can be conducted through the melt, overheating of the surface layer ensues and the loss of zinc becomes prohibitive. Hence electric furnaces of the direct or indirect arc types used for steel are not applicable to a brass high in zinc. The ordinary horizontal-ring induction furnace is not applicable because of "pinch" troubles due to the high electrical conductivity of the alloy. Alloys that approach steel in their nature rather than brass, for example the nonvolatile nickel alloys, such as nichrome and monel metal, can be and are successfully melted in ordinary direct arc furnaces used for steel, like the Heroult, Greaves-Etchell and Snyder. Nichrome can be handled in the ordinary induction furnace. True bronzes can be melted by a direct arc. Direct-arc furnaces of the roof-opening type allow rapid charging and are favored in one installation on bronze where rapid production is the chief aim.

Melt Pure Copper

Pure copper ought to be capable of being melted with a direct arc, but according to Hansen's experience doing so caused volatilization of copper and copper poisoning of the workmen. It is probable that this trouble, or the lack of it, depends again on the relative rate at which heat is supplied and that at which it is conducted through the melt. A high-powered arc in contact with the charge evidently causes some volatilization of copper. Less severe and less local heating is obtained in indirect arc furnaces. The U. S. mint has had fine success on coinage nickel, bronze, and silver, with Rennerfelt indirect arc furnaces.

Silver is slightly volatile and a direct arc-type furnace would hardly be applicable. The indirect arc-type furnace is, the U. S. mint having melted 3,000,000 pounds (1,363,000 kilograms) of silver dollars with a metal loss of 0.01 per cent.

The new von Schlegell *repelling arc* furnace, which may be operated either as a direct or an indirect current furnace, is being applied to nonferrous melting. If the self-starting and automatic regulating scheme proves mechanically and electrically feasible, this furnace may be of value on those alloys that can be melted in direct or stationary indirect-arc furnaces.

When we come to the common red brasses, which contain say 5 per cent zinc the direct arc is not suitable, and at about 20 per cent zinc the stationary indirect arc also proves unsatisfactory. When we get to the important yellow brasses of 30 to 40 per cent zinc or to nickel brasses, we are forced to abandon the standard steel furnace types and strike out on new paths. This necessity has been the mother of a number of interesting and ingenious methods of avoiding the difficulty.

Three general methods have been followed:

Using a low rate of power input.

Using a high rate of power input, and stirring by moving the furnace.

Heating from within the metal itself, with inherent stirring.

A low rate of power input means low efficiency and low production. When the heat is mainly indirectly transmitted from the source to the charge by reflection from the roof in order to distribute it more evenly, refractory problems are made rather difficult. Various furnace builders attack the problem with furnaces of this general type in different ways.

Bennett builds his furnace like a regular three-phase direct-arc furnace, but holds the voltage down so that he gets contact resistance rather than true arcs, and by holding down the rate of power input, allows time for equalization of temperature and avoidance of local superheating. By generating the heat close to the charge he avoids much of the thermal loss found with other low-powered types.

The largest electric brass furnace in use is of this type, though it has not been introduced into the industry outside the plant of the inventor.

Uses Granular Resistor

Baily uses a large, relatively low temperature source of heat, a single-phase granular resistor, and still further distributes the heat by reflecting the bulk of it from the roof. A low rate of power input is used, partly on account of the limitations due to the resistor troughs, and a furnace results which is slow, giving low production, sluggish, with a high heat storage and of low thermal efficiency, especially when not run continuously. However, the furnace is simple, and easy to operate and for this reason has had a large measure of success.

The furnace made by the General Electric Co., applies heat in much the same manner as the Baily furnace, but by using the smothered-arc or contact-resistance principle, it can use a higher rate of power input, gaining somewhat in thermal efficiency, but increasing the

Paper prepared for the meeting of the American Electrochemical society held at Atlantic City, April 21-23. The author is connected with the United States bureau of mines, Ithaca, N. Y.

Table I

Electric Furnaces in Active Commercial Use on, or Being Installed for, Nonferrous Alloys in the United States, January 1, 1921

Make	No.	User	Alloy	Capacity tons per heat per furnace	Total capacity tons	Kw. rating	Total kw.
DIRECT ARC FURNACES							
Heroult[1]	2	Driver-Harris Co., Harrison, N. J.	nickel alloys	2	4	800	1,600 [2]
Greaves-Etchell	1	Hoskins Mfg. Co., Detroit	" "	½	½	300	300 [2]
Snyder	1	Monel Metal Products Co., Bayonne, N. J.[3]	monel	½	½	100	100 [4]
"	1	Chrobaltic Tool Co., Chicago	cobalt chromium	⅛	⅛	60	60 [4]
"	3	Haynes Stellite Co., Kokomo, Ind.	" "	⅛	⅛	60	240 [4]
"	2	Chicago Bearing Metal Co., Chicago	leaded bronze	1	2	400	800 [5]
Total	10	Number of users, 6			7½		2,100
STATIONARY INDIRECT ARC FURNACES							
Rennerfelt[6]	1[7]	Chicago Bearing Metal Co., Chicago	leaded bronze	1	1	300	300 [8]
"	1	United States Mint, Philadelphia	bronze and silver	½	½	150	150 [9]
"	1	United States Mint, Philadelphia	" " "	1	1	300	300 [9]
"	1	United States Mint, San Francisco	" " "	½	½	125	125 [9]
"	1	Bausch Machine Tool Co., Springfield, Mass.	hardeners for Al.	⅛	⅛	100	100 [9]
"	1	Hardite Metals Co., Long Island City, N. Y.	nickel chromium	½	½	150	150 [9]
Von Schlegell[10]	1	Chicago Bearing Metal Co., Chicago	leaded bronze	1	1	450	450[11]
" "	2	Crane Co., Chicago	monel and bronze	3/20	3/10	50	100[11]
" "	1	Sandusky Foundry & Machine Co., Sandusky, O.	bronze	3/20	3/20	50	50[11]
" "	1	Manning, Maxwell & Moore, Inc., Bridgeport, Conn.	"	3/20	3/20	50	50[11]
Total	11	Number of users, 7			6		1,775
MOVING INDIRECT ARC FURNACES—SINGLE PHASE[12]							
Detroit Rocking	2	Aluminum Mfg. Co., Inc., Detroit	brass and bronze	1	2	300	600
" "	2	American Bushing Corp., Marysville, Mich.	" " "	1	2	300	600
" "	2	American Manganese Bronze Co., Holmesburg, Pa.	" " "	1	2	300	600
" "	1	Bethlehem Shipbuilding Co., Redington, Pa.	" " "	1	1	300	300
" "	5	C. B. Bohn Foundry Co., Detroit	brass, bronze & Al.	1	5	300	1,500
" "	2	Bound Brook Oilless Bearing Co., Bound Brook, N. J.	bronze	½	1	150	300
" "	1	Bridgeport Brass Co., Bridgeport, Conn.	bronze and copper	1	1	300	300
" "	4	Chase Metal Works, Waterbury, Conn.	brass	1	4	300	1,200
" "	1	Cleveland Brass & Copper Rolling Mills, Cleveland	"	1	1	300	300
" "	8[13]	Detroit Copper and Brass Rolling Mills, Detroit	"	1	8	300	2,400[14]
" "	1	Ford Motor Co., Detroit	brass and bronze	1	1	300	300
" "	1	Ford & Son, Dearborn, Mich.	" " "	1	1	300	300
" "	2	General Aluminum & Brass Mfg. Co., Detroit	" " "	1	2	300	600
" "	1	General American Tank Car Corp., Chicago	" " "	½	1	150	150
" "	1	Lumen Bearing Co., Buffalo	" " "	½	½	150	150[15]
" "	1	Hills, McCanna Co., Chicago	" " "	¼	¼	75	75
" "	2	Michigan Lubricator Co., Detroit	" " "	1	2	300	600
" "	4	Michigan Smelting & Refining Co., Port Huron, Mich.	" " "	1	4	300	1,200
" "	2	Mueller Metals Co., Port Huron, Mich.	brass	1	2	300	600
" "	1	Oregon Brass Works, Portland, Oreg.	brass and bronze	1	1	300	300
" "	1	Oregon Brass Works, Portland, Oreg.	" " "	½	½	150	150
" "	3	Parish Pool Co., Cleveland	" " "	1	3	300	900[16]
" "	1	Rome Wire Co., Rome, N. Y.	copper	1	1	300	300
" "	1[17]	Standard Underground Cable Co., Perth Amboy, N. J.	brass and Cu.	1½	1½	300	300[18]
" "	3	Sherwood Brass Works, Detroit	brass and bronze	1	3	300	900
" "	1[17]	Sarachan & Rosenthal, Inc., Rochester, N. Y.	brass	1	1	300	300
" "	1	M. Smolensky Mfg. Co., Cleveland	"	¼	¼	75	75
" "	1	White & Bros., Philadelphia	brass and bronze	1	1	300	300
" "	1	Wheeler Condenser & Engineering Co., Carteret, N. J.	" " "	1	1	300	300
	57	Number of users, 28				53	15,900
Booth	3	The full list of users of Booth furnaces is not available, as it is not given out by the makers. Among the users are Cleveland Brass Co., Cleveland; Dearborn Brass Co., Cedar Rapids, Iowa; Dallas City Foundry Co., Dallas City, Ill.; Fulton-Harwood Brass Works, South Bend, Ind.; National Bronze and Aluminum Foundry, Cleveland; Michigan Smelting and Refining Co., Detroit; Muskegon Aluminum Foundry Co., Muskegon, Mich.; Yale & Towne, Stamford, Conn.; Hill Pump Valve Co., Chicago; Nordyke & Marmon Co., Indianapolis; Prime Mfg. Co., Milwaukee. Some of the Booth furnaces have automatic control.		1	3	300	900
"	4			½	2	180	720
"	25			⅛	6¼	125	3,125
"	8			⅛	2	75	600
	40	Number of users of Booth furnaces, 35-40			13¼		5,345
American	1	York Hardware & Brass Co., York, Pa.	brass and bronze	½	½	300	300
Grand tot'l for type	98	Number users of type, about 65			67		21,545
REFLECTED HEAT FURNACES							
Baily	1	Acheson Mfg. Co., Rankin, Pa.	brass and bronze	¾	¾	105	105
"	1	Akron Bronze & Aluminum Co., Akron, O.	" " "	¾	¾	105	105
"	1	Akron Bronze & Aluminum Co., Akron, O.	" " "	⅛	⅛	50	50
"	1	Allis Mfg. Co., Milwaukee	" " "	⅛	⅛	50	50
"	1	American Hardware Corp., New Britain, Conn.	" " "	¾	¾	105	105
"	1	Anaconda Copper Mining Co., Butte, Mont.	" " "	¾	¾	105	105
"	1	Atlas Brass Works, Columbus, O.	" " "	¾	¾	105	105
"	2	Buick Motor Car Co., Flint, Mich.	" " "	¾	1½	105	210
"	2	Burlington Brass Works, Burlington, Wis.	" " "	¾	1½	105	210
"	2	Capitol Brass Co., Detroit	" " "	¾	1½	105	210
"	1	Chapman Valve Co., Springfield, Mass.	" " "	¾	¾	105	105
"	1	Coppus Eng. & Equipment Co., Worcester, Mass.	" " "	¾	¾	105	105
"	1[17]	Claus Auto Gas Co., Milwaukee	" " "	½	½	75	75
"	1	Dayton Engineering Laboratory Co., Dayton, O.	aluminum	1/5	1/5	105	105
"	2	Dayton Engineering Laboratory Co., Dayton, O.	brass and bronze	⅛	⅛	50	100
"	1	Deming Co., Salem, O.	" " "	⅛	⅛	50	50
"	3	Detroit Brass Works, Detroit	brass	¾	2¼	105	315
"	1	Drew Electric & Mfg. Co., Cleveland	brass and bronze	¾	¾	105	105
"	1[19]	Evinrude Motor Co., Milwaukee	" " "	½	½	75	75
"	1[19]	Flood City Mfg. Co., Johnstown, Pa.	" " "	½	½	75	75
"	1	Hays Mfg. Co., Erie, Pa.	brass	¾	¾	105	105

Table I (*Continued*)

Make	No.	User	Alloy	Capacity tons per heat per furnace	Total capacity tons	Kw. rating	Total kw.
"	1	Keyline Co., Cleveland	brass and bronze	¼	¼	50	50
"	1	Kennedy Valve Co., Elmira, N. Y.	" " "	¾	¾	105	105
"	1	Landers, Frary & Clark, New Britain, Conn.	aluminum	1/10	1/10	50	50
"	2	Lumen Bearing Co., Buffalo	brass and bronze	¾	1½	105	210
"	1	Lumen Bearing Co., Buffalo	Lumen metal	½	½	105	105
"	1	Miller Pasteurizing Machine Co., Canton, O.	brass and bronze	¼	¼	50	50
"	4	Michigan Smelting & Refining Co., Detroit	brass	¾	3	105	420
"	1	A. Y. McDonald Co., Dubuque, Iowa	brass and bronze	¾	¾	105	105
"	1	McKenna Brass Works, Pittsburgh	" " "	¾	¾	105	105
"	1	McKenna Brass Works, Pittsburgh	" " "	¼	¼	50	50
"	2	Metric Metals Co., Erie, Pa.	" " "	½	1	75	150
"	3	McRae-Roberts Co., Detroit	" " "	¾	2¼	105	315
"	1(19)W. A. Mills, Port Chester, N. Y.	" " "	½	½	75	75
"	3	Nolte Brass Co., Springfield, O.	" " "	¾	2¼	105	315
"	1	Oro Metals Co., Los Angeles	" " "	¾	¾	105	105
"	1	H. Orne & Sons, St. Paul, Minn.	" " "	½	½	75	75
"	1	Penberthy Injector Co., Detroit	" " "	¾	¾	105	105
"	1	Pittsburgh Valve & Fixture Co., Barberton, O.	" " "	¾	¾	105	105
"	1	Regent Brass Works, Marysville, O.	" " "	¾	¾	105	105
"	1	Rundle Mfg. Co., Milwaukee	" " "	½	½	75	75
"	1	Springfield Brass Works, Springfield, O.	" " "	¾	¾	105	105
"	5	Standard Sanitary Co., Louisville, Ky.	" " "	¾	3¾	105	525
"	1	Sperry Gyroscope Co., New York	" " "	½	½	75	75
"	1	S. H. Thomson Mfg. Co., Dayton, O.	" " "	¼	¼	50	50
"	2	Union Brass & Metals Mfg. Co., St. Paul, Minn.	" " "	¾	1½	105	210
"	1	Union Screen Plate Co., Fitchburg, Mass.	brass and bronze	½	½	75	75
"	1	United States Copper Products Co., Cleveland	brass	¾	¾	105	105(20)
"	1	United States Navy Yard, Washington	brass and bronze	¾	¾	105	105(20)
"	1	Utica Valve & Fixture Co., Utica, N. Y.	" " "	¾	¾	105	105
"	1	Westinghouse Electric Mfg. Co., East Pittsburgh, Pa.	" " "	¼	¼	50	50
"	2	West Virginia Metal Products Co., Fairmont, W. Va.	" " "	¾	1½	105	210(20)
"	1	White & Bros., Philadelphia	" " "	¾	¾	105	105
"	1	J. B. Wise, Inc., Watertown, N. Y.	" " "	½	½	75	75
"	1	Wolverine Brass Works, Grand Rapids, Mich.	" " "	¼	¼	50	50
	76	Number of users, 51			48		6,890
General Electric	1	General Electric Co., Schenectady, N. Y.	aluminum	1/13	1/13	75	75
" "	1	General Electric Co., Schenectady, N. Y.	"	¼	¼	150	150
" "	1	General Electric Co., Schenectady, N. Y.	brass and bronze	¾	¾	250	250
" "	1	McNab & Harlin Mfg. Co., Paterson, N. J.	"Aterite"	¾	¾	300	300
" "	1	McNab & Harlin Mfg. Co., Paterson, N. J.	"	1⅓	1⅓	400	400
" "	1	United States Copper Products Co., Cleveland	brass and copper	1⅓	1⅓	400	400
" "	1	Ohio Brass Co., Mansfield, O.	brass and bronze	1⅓	1⅓	400	400
" "	1(22)United States Navy Yard, Washington	" " "	1⅓	1⅓	400	400
" "	1(22)Standard White Metals Co., Elyria, O.	aluminum	¾	¾	125	125
	9	Number of users, 6			6½		2,500
Rennerfelt Reverberatory	1	Chicago Faucet Co., Chicago		3/20	3/20	75	75
Total for type	86	Number of users, 58			55		9,465

VERTICAL RING INDUCTION FURNACES—SINGLE PHASE

Ajax-Wyatt	3	Ajax Metal Co., Philadelphia	yellow brass	1/6	¾	30	90
" "	16(22)American Brass Co., Waterbury, Conn.	" "	½	8	60	960
" "	24	American Brass Co., Kenosha, Wis.	" "	⅔	12	60	1,440
" "	1	American Hardware Co., New Britain, Conn.	yellow & red brass	1/6	1/6	30	30
" "	6	Baltimore Tube Co., Baltimore	yellow brass	½	3	60	360
" "	12(24)Bridgeport Brass Co., Bridgeport, Conn.	" "	1/3	4	45	540
" "	2	Bridgeport Brass Co., Bridgeport, Conn.	" "	¾	1½	80	160
" "	1	Buick Motor Car Co., Flint, Mich.	" "	½	½	60	60
" "	2(25)Chase Rolling Mill Co., Waterbury, Conn.	" "	½	1	60	120
" "	1	Crane Co., Chicago	red brass	½	½	60	60
" "	1	Erie-Buffalo Tube Co., Erie, Pa.	yellow brass	½	½	60	60
" "	1	General Electric Co., Schenectady, N. Y.	" "	½	½	60	60
" "	1	Haines, Jones & Cadbury, Philadelphia	red brass	½	½	60	60
" "	6	National Conduit & Cable Co., Hastings, N. Y.	yellow brass	¾	3	60	360
" "	1	Raritan Copper Works, Raritan, N. J.	" "	½	½	60	60
" "	1	Parish Pool Co., Cleveland	" "	½	½	60	60
" "	2	Rome Brass & Copper Co., Rome, N. Y.	" "	½	1	60	120
" "	2	Scovill Mfg. Co., Waterbury, Conn.	" "	½	1	60	120
" "	1	Speakman Co., Wilmington, Del.	" "	½	½	60	60
" "	1	Specialty Brass Co., Kenosha, Wis.	" "	½	½	60	60
" "	1	Stamford Rolling Mills Co., Stamford, Conn.	" "	½	½	60	60
" "	1	Standard Sanitary Mfg. Co., Louisville, Ky.	" "	½	½	75	75
" "	2	Standard Underground Cable Co., Perth Amboy, N. J.	" "	½	½	60	120
" "	1	W. A. Clark Wire Co., Bayway, N. J.	" "	½	½	60	60
" "	6	West Virginia Metal Products Co., Fairmont, W. Va.	" "	½	3	60	360
" "	1	Western Cartridge Co., West Alton, Ill.	" "	½	½	60	60
	1	United States Navy Yard, Washington		⅛	⅛	60	60
	98	Number of users, 25			45		4,635
	70	Planned for prompt installation			35		4,200
Total	168				80		8,835

HORIZONTAL RING INDUCTION FURNACES—SINGLE PHASE

General Electric	1	Hoskins Mfg. Co., Detroit	nickel chromium	⅛	⅛	100	100

CONTACT RESISTANCE FURNACES—THREE-PHASE

Bennett	1	Scovill Mfg. Co., Waterbury, Conn.	brass and copper	5	5	500	500
"	6	Scovill Mfg. Co., Waterbury, Conn.	" " "	1	6	150	900

Table I (*Continued*)

Make	No.	User	Alloy	Capacity tons per heat per furnace	Total capacity tons	Kw. rating	Total kw.
					11		1,400
		HIGH FREQUENCY EDDY CURRENT FURNACES					
Ajax-Northrup	1	Baker & Co., Newark, N. J.	platinum	..	..	20	20[26]
" "	1	H. A. Wilson Co., Newark, N. J.	"	..	..	20	20[26]
" "	1	D. Belais, New York	"white gold"	..	..	20	20[26]
" "	1	J. R. Wood & Sons, New York	gold	..	..	20	20[26]
" "	2	United States Mint, Philadelphia	silver	..	..	8	6[27]
" "	2	United States Mint, Philadelphia	"	..	..	16	32[27]
" "	1	Handy & Harman, Bridgeport, Conn.	"	¼	¼	60	60[28]
	9	Number of users, 6			¼+		188
		OTHER CRUCIBLE LIFT-OUT FURNACES					
Baily	1	W. A. Rogers, Ltd., Niagara Falls, N. Y.	silver	1/30	1/30	40	40[29]
Marsh	2[30]	Hoskins Mfg. Co., Detroit	nickel chromium	1/20	1/10	50	100[31]
	3	Number of users, 2			2/15		140

[1] Another Heroult furnace melting nickel alloys is installed at Hiram Walker Metal Products Co., Walkerville, Ontario, Canada.
[2] Three-phase automatic control.
[3] According to Diller, H. E., Foundry Standardizes nickel alloy, Foundry, Vol. 48, 1920, p. 210. A 2-ton electric furnace is later to be installed at this plant.
[4] Single-phase.
[5] Single-phase, automatic control.
[6] A ½-ton 100 kilowatt Rennerfelt for melting monel, bronze and brass up to 22 per cent zinc is installed at the Gerline Brass Foundry Co., Kalamazoo, Mich., but has not been in service for some time on account of power shortage.
[7] A second 1-ton Rennerfelt at this plant has been made over into a Von Schlegell furnace.
[8] Two-phase.
[9] Two-phase; nose tilting and automatic control.
[10] Von Schlegell repelling arc furnace may be operated either as direct or indirect arc furnace.
[11] Three-phase.
[12] A three-phase oscillating indirect arc furnace, the Volta, has been tried out in a 1-ton 300 kilowatt size at the Titanium Bronze Co., Niagara Falls, N. Y., but that firm has ceased operations.
[13] Four installed, four being installed.
[14] Direct pouring furnaces.
[15] Automatic control.
[16] Two direct pouring.
[17] Being installed.
[18] Direct pouring, standard furnace, lined for larger charge.
[19] Being installed.
[20] Nose tilting.
[21] Two 105 kilowatt furnaces are also used by Metal & Thermit Co., Chicago, for tin recovery. Other Baily furnaces are installed in Canada and Mexico as follows: Canada, Empire Brass Works, one 105 kilowatt; Monarch Metal Co., one 50 kilowatt; Dominion Steel Products Co., one 50 kilowatt; Mexico, G. Amsinck Corp., two 105 kilowatt.
[22] Being installed.
[23] This firm plans to double its Waterbury installation and install 24 furnaces, 60 kilowatt size, at the Torrington, Conn., plant. Installation of some of these furnaces is under way.
[24] This firm originally used mostly the 30 kilowatt size, but has changed to a smaller number of higher powered furnaces, and contemplates doubling its present installation when business conditions permit.
[25] This firm plans to install about 30 more 60 kilowatt furnaces, part of this installation being under way at present. Exact information is lacking as to how many of these furnaces planned for future installation are being installed at present.
[26] Single-phase, crucible lift-out.
[27] Two-phase, crucible lift-out.
[28] Three-phase, nose-tilting.
[29] Single-phase, two crucibles.
[30] These furnaces are used less than formerly on account of the installation of larger furnaces of other types.
[31] Single-phase, one or two crucibles per furnace.

difficulties with the refractories due to the higher temperature of the heat source. Three-phase power can be used instead of single-phase. Considering the time it has been on the market, it has found relatively little use.

The Rennerfelt *electric reverberatory* furnace is just like the General Electric furnace in its source of heat, but locates this in the middle of the furnace instead of around the sides, and consequently wastes less energy in heating the furnace walls instead of the charge. One small furnace of this type has shown promising results. If structural difficulties do not become too great in larger furnaces, it should find considerable use.

The next method of avoiding the specific difficulties found with alloys high in zinc is to use an indirect-arc furnace, with a high rate of power input to get thermal efficiency, and to move the furnace so as to stir the metal and avoid superheating the surface. This was done long ago by Stassano in the early days of electric steel, but such furnaces were not then applied to brass. The principal applications of this method are the Detroit rocking furnace (operating under license from the bureau of mines) and the Booth rotating furnace, the former being installed almost wholly in the one-ton size, and the latter almost wholly in 500-pound or even smaller sizes. These furnaces give good efficiency, even on an eight-hour day, and have been adopted by the industry with remarkable rapidity. They are capable (especially the Detroit, which can be mechanically charged from overhead) of rapid operation and high production.

A similar furnace, the American, has been introduced by Ryan, but only one installation has yet been made. All these furnaces are single phase.

A polyphase furnace, the Moore *Rapid 'Lectromelt* has been advertised for sale and is stated to fall into the moving-indirect-arc class, but nothing more than experimental operation has as yet been credited to this furnace and its details are still shrouded in mystery.

The old gyrating Stassano furnace has very recently been resurrected at the hands of the Volta Mfg. Co., provided with a simpler gyratory mechanism, renamed the *Volta*, and applied to brass. One of these furnaces has been tried experimentally in a foundry for a short while, but little data are yet available, so the adequacy of the stirring is not yet known. It has the advantages of three-phase operation, but lacks the ability of the rocking type to take up heat from the roof into the melt.

One other possibility deserves mention, though it is not yet in use. The rocking, rotating, or gyrating Thomson-Fitzgerald design has a solid slotted resistor as the source of heat, and the furnace is moved to stir the charge. As not even the *aspirations* of the inventors have yet been publicly voiced, though the furnace was once advertised for sale, and data on its performance are lacking, further discussion is not called for here.

We now come to the third method

Table II

Summary of Table I

Make	Total capacity per heat tons	Total kilowatt	Number furnaces	Number users
Ajax-Wyatt	45	4,635	93	25
Detroit Rocking	53	15,900	57	28
Baily	48	6,890	76	51
Booth	13	5,345	40	35
Other furnaces	34	9,580	52	30
Total in use	193	42,350	318	169
Ajax-Wyatt, planned for prompt installation	(35)	(4,200)	(70)	25 duplicates
Total including Ajax-Wyatts planned	228	46,550	388	144 separate users

of meeting the idiosyncrasies of brass. Hering's work on the pinch effect was the starting point for those furnaces which use the metal itself as resistor and by virtue of various electromagnetic effects, such as the pinch effect and the motor effect, cause circulation of the metal. The Hering furnace was tried on brass on a considerable scale but is no longer in use. Hering has a plan for overcoming the difficulties with the metallic electrodes.

Foley has made large-scale experiments on a vertical-ring induction furnace in which the hydrostatic head of the molten metal opposes the pinch force, but at last reports his furnace is not in the commercial stage.

The Ajax-Wyatt vertical-ring induction furnace, with its internal heating in the metal itself, its automatic circulation, and its compact form, has shown astonishing thermal efficiency and has been adopted generally by those brass rolling-mill industries which can readily melt 24 hours a day and need not often change a furnace from one alloy to another—conditions vital to the successful operation of this furnace As these conditions are seldom found in the foundry, as differentiated from the rolling mill, it has had little foundry use. It is in general not applicable to alloys of high electrical conductivity, *i. e.*, those high in copper

It is rumored that the General Electric Company may soon complete the development of a horizontal-ring induction furnace for both steel and nonferrous alloys, but data on the progress of the work are not available.

The last type that deserves mention is the ingenious high-frequency eddy-current Ajax-Northrup furnace. This is in commercial use on silver, platinum, etc., and besides the commercial installations some 25 furnaces are being used in laboratories on account of their extreme flexibility.

The furnace itself is highly successful for its special applications, and may be expected to find large commercial use if and when the generation of the necessary high-frequency current is so developed and cheapened that normal sized Ajax-Northrup furnaces are practical.

It appears that with this array of furnaces any brass melter can find an electric furnace of at least fairly well-proven ability, to handle his work, as there are many types and many sizes of most types. If he cannot use a single-phase furnace owing to limitations of his power supply, he can probably find a three-phase type that will serve. As a matter of fact, the furnace in widest use, the Ajax-Wyatt, Baily, Booth and Detroit, are all single-phase.

If the furnace is chosen so as to be metallurgically fit for its work, for example, if a direct-arc or a stationary indirect-arc furnace on yellow brass is avoided, and if they are run closed when melting yellow brass so that zinc vapor does not escape, all the furnaces show marked savings in metal losses. Labor costs are low, as the furnaces

Table III

Applicability of Various Types of Electric Furnace to Various Alloys

Alloys									Types of Furnaces						
Fe	Cr	Ni	Cu	Sn	Pb	Zn	Ag	Al	Direct Arc	Stationary Indirect Arc	Moving Indirect Arc	Reflected Heat	Contact Resistance (Bennett)	Vertical Ring Induction	High Frequency
..	15	85	..	..	..	..	..	..	O. K.	O. K.	O. K. ?	? 1	?	?	O. K. ?
5	..	67	28	..	..	..	..	..	O. K.	O. K.	O. K. ?	? 1	?	?	O. K. ?
..	..	25	75	..	..	..	..	..							
..	..	5	95	..	..	..	..	..	? 2	O. K.	O. K.	O. K.	O. K. ?	?	O. K. ?
..	..	..	100	..	..	..	..	..	? 2	O. K.	O. K.	O. K.	O. K.	No-3	O. K.
..	..	..	90	10	..	..	..	..							
..	..	..	88	10	2	..	..	..	O. K.	O. K.	O. K.	O. K.	O. K. ?	? 3	O. K.
..	..	..	80	10	10	..	..	..	O. K. 5	O. K.	O. K.	O. K.	O. K. ?	No-4	O. K.
..	..	..	76	3	18	3	..	..							
..	..	..	68	4	26	2	..	..	No-5	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.
..	..	..	85	5	5	5	..	..							
..	..	..	74	4	5	17	..	..	No-5	No-5	O. K.	O. K.	O. K.	O. K.	O. K.
..	..	..	80	..	..	20	..	..							
..	..	..	70	..	..	30	..	..							
..	..	..	67	..	3	30	..	..							
..	..	..	61	1	..	38	..	..	No-5	No-5	O. K.	O. K.	?	O. K.	O. K.
..	..	..	65	..	1	34	..	..							
..	..	..	60	..	..	40	..	..							
..	..	18	58	..	..	24	..	..							
..	..	..	3	..	..	15	..	85	No-5	? 5	O. K.	O. K.	?	? 3	O. K.
..	..	..	2	..	..	30	..	68							
..	..	..	8	..	..	..	..	92	?	O. K. ?	O. K.	O. K.	?	? 3	O. K.
..	..	..	10	..	..	..	90	..	?	O. K.	O. K. ?	O. K. ?	?	? 3	O. K.
..	..	..	10	..	..	85	..	5	No	No-5	O. K. ?	O. K.	?	?	O. K. ?

O.K. = Furnace metallurgically satisfactory for this alloy.
? = No data on hand.
O.K.? = Probably satisfactory, but no record of trial.
No. = Furnace not satisfactory for this alloy.
1 = Temperatures probably rather high for good refractory life.
2 = Question of copper poisoning by fume from direct arc not yet settled.
3 = Induction furnace on this alloy would require resistor tube of special design.
4 = Lead too high for good life of usual lining of induction furnace.
5 = Furnace causes loss of volatile metal from this alloy.

either require little attendance or can be supplied with automatic control and the writer believes they will be increasingly so supplied.

Power costs are a function of the price of power, the continuity of use of the furnace, and of the thermal efficiency of the furnace. At war-time prices for fuel, electric melting was cheaper on nearly all nonferrous alloys in nearly all locations, with almost any electric furnace. With fuel prices nearer normal the innate thermal efficiency of the furnace and the operation of a given furnace as nearly continuously and with as few delays as possible, so as to develop the highest possible thermal efficiency, will become increasingly important.

When the electric furnace replaces crucible furnaces it effects a large saving in that item. In calculating the savings possible by electric melting, one should not forget, as some electric furnace salesmen are prone to do, that the electric is high in first cost and that interests, depreciation and obsolescence charges cannot be disregarded. These charges, per ton, are minimized by operation that gives maximum production, *i. e.*, steady operation on 24 or 16 hour schedules instead of 8 or 10, cutting down delays in time of pouring and charging, and keeping up to the maximum allowable rate of power input.

The most important of all points about any furnace, its ability to produce metal of the desired quality, has not been mentioned, because without it, no furnace can be used.

It is doubtful if the electric furnace has produced any better brass than the best from the old crucible in a pit-fire, but due to the larger melts and the stirring produced by some furnace types, electric brass is probably more homogeneous and more uniformly good than that from fuel-fired furnaces.

Commercially Economical

The list of users in Table I is sufficient proof that the electric brass furnace gives a good quality of product. This same list, better than any other evidence, proves too that electric melting of nonferrous alloys is commercially economical.

The electric brass furnace today occupies a position of greater relative importance in the brass industry than the electric steel furnace does in the steel industry, and has reached this position in a much shorter time.

Of commercially important nonferrous metals and alloys other than brass and bronze there have already been mentioned the nickel alloys, silver and platinum. Aluminum remains to be considered. The electric melting of aluminum has not progressed as far as that of brass and bronze. The large latent heat of fusion of aluminum makes it require a good deal of energy for melting, theory calling for twice as much energy to melt aluminum and heat it to pouring temperature as to melt and heat yellow brass to its much higher pouring temperature. Hence production is slower on aluminum than on brass. Moreover, at these low temperatures fuel-fired furnaces are relatively more efficient than they are at higher temperatures, so that the electric furnace has stronger competition. A large Baily furnace has been tried out on the preparation of aluminum alloy ingots and worked well on aluminum zinc alloys, as it reduced zinc loss. But there is not a sufficient tonnage of aluminum-zinc alloys used in the country to keep this furnace busy, and as it did not show any advantage on other aluminum alloys it was discarded. A smaller Baily was tried by another ingot producer and also discarded.

Question To Be Solved

Several aluminum foundries use Baily furnaces on aluminum, however, and the General Electric Co. uses its furnace for that purpose. The Detroit furnace also has given good results on aluminum. The General Electric Co. is developing an aluminum furnace with a Ni-Cr resistor which ought to be feasible at the temperature involved and its use should throw light on the interesting question of whether a more or less reducing atmosphere, as in a carbon resistor or arc furnace, or an oxidizing one, as in the Ni-Cr furnace, is the better for aluminum.

On the usual aluminum alloys the electric furnace does not show any particular saving in metal. Its economical use in comparison with fuel-fired furnaces will depend on prices of fuel and of power. It is of service where close temperature control is essential.

Cathode zinc has been melted in a 1000-kilowatt Baily furnace, but the furnace was not found satisfactory and was discarded.

Baily furnaces of 100 kilowatt, however, are used successfully in the production of an alloy of 85 percent zinc, 10 copper and 5 aluminum.

For alloys of still lower melting points, babbitt, solder, type metal, etc., there are metallic resistor furnaces, but they have found little use.

Electric melting, then, is thoroughly established on brass, well established on bronze, common on nickel-chromium, and similar alloys, growing on silver and other precious metals, has only a foothold in aluminum, and is unusual on lower melting alloys.

There are possibilities for greater use of the electric furnace on some of these alloys, and perhaps, though this seems doubtful, in the large scale melting of cathode copper. Instead of any further spectacular extension of electric melting to other nonferrous alloys, the immediate future seems to promise merely a gradual growth, electric furnaces finding new applications in specific cases from time to time rather than all at once and in an industry as a whole, as was the case with brass.

Discussion of *best practice* in nonferrous electric melting in general is impossible, because best practice depends on what alloys are to be melted, in what furnaces they are to be melted, and on many varying plant conditions. A special technique, though one readily acquired, is needed for each furnace under each set of conditions, so no attempt will be made here to state whether the night watchman should turn the current onto a Baily furnace at midnight or at 4 a.m. in order to get it properly preheated for the day's run or whether a one-ton Detroit furnace should start rocking after 75 or 100 kilowatt-hours has been used on a given heat. There are interesting possibilities in preheating the charge by fuel before putting it into the electric furnace, and in the use of two furnaces with one set of electrical equipment, so that one furnace is melting while the other is pouring and charging, and the electrical equipment is kept busy all the time, the load factor kept up and the maximum demand cut down. These ideas will undoubtedly work out in specific instances, but not in all.

Such points have to be solved by the past general experience of the maker of the furnace selected plus the user's specific knowledge of his own conditions and his own problems.

Conditions Govern

The fundamental requirement for good performance of an electric furnace on nonferrous alloys is that the furnace be fitted for its job. Under some plant conditions half a dozen different furnaces might give equally good results, more commonly only a couple ought to be considered, often one is pre-eminently suitable, and sometimes (but in the case of brass and bronze very rarely) no electric furnace can properly compete with the most suitable fuel-fired furnace. Nevertheless, experience has shown that an electric furnace, metallurgically suited to its job, once installed generally stays in service, even though the melting cost sheets may show no saving. That is,

the advantage of ease of control, cleanliness, and less trying working conditions for the furnace tender, which can hardly be expressed in terms of dollars and cents, are as real reasons for the adoption and use of electric furnaces as the more obvious reason that it generally costs less per unit to melt in the electric furnace.

British Associations Honor Publisher

IN RECOGNITION of his work in fostering co-operative effort among the leading producers of iron and steel products in the United States, a complimentary dinner was tendered John A. Penton, honorary president of the American Malleable Castings association, secretary of the American Pig Iron association and president of the Penton Publishing Co., Cleveland, at the Queen's hotel, Birmingham, England, on Thursday, May 12. The dinner was given jointly by six of the leading British associations in the metallurgical field, including the Staffordshire Iron and Steel institute, the British Cast Iron Research association, the Birmingham and the Coventry branches of the Institution of British Foundrymen, the Midland Ironfounders' association, the Malleable Ironfounders' association, and the Birmingham Metallurgical society.

Prof. Thomas Turner, head of the metallurgical department of Birmingham university, and known the world over for his researches on the effect of silicon in cast iron, presided. The guest of the evening was introduced by the deputy lord mayor of Birmingham, Alderman Sir William Bowater. Among those present were: Frank Somers, J. P., past president, Staffordshire Iron and Steel institute, who had charge of the committee on arrangements; F. J. Cook, chairman, Midland Ironfounders' association; Joseph Payton, president, Staffordshire Iron and Steel institute; H. B. Weeks, chairman of council, British Cast Iron Research association; A. E. Hurst, chairman, Malleable Ironfounders' association; A. Spittle, president, Birmingham Metallurgical society; C. B. Pugh, secretary, Staffordshire Iron and Steel institute; H. L. Reason, vice president, Institution of British Foundrymen; R. Buchanan, first president, Institution of British Foundrymen; J. R. Hyde, president, Sheffield Branch, Institution of British Foundrymen; H. Field, president, Birmingham branch, Institution of British Foundrymen; E. Carey Hill, president Coventry branch, Institution of British Foundrymen; C. and J. F. Retallack, John Harper & Co., Ltd., Willenhall; W. Oubridge, British Piston Ring Co., Coventry; O. Harmer, Alfred Herbert, Ltd., Coventry; Major P. Jump, N. Hingley & Co., Dudley; J. Hassall, Hassall & Singleton, Birmingham; J. Moseley, Moseley & Son, Birmingham; T. Gameson, Gameson & Son, Birmingham; W. H. Wood, Constructional Engineering Co., Birmingham; William O'Keefe and H. Roe, Adatable Moulding Machine Co., Birmingham; Joseph Horton and A. J. Garbutt, Horton & Garbutt, Birmingham; V. C. Faulkner; W. A. Homer; A. J. G. Smout; W. Proctor; S. A. Hill; F. H. N. Lane; M. R. Bethell; M. Slater; D. Lewis; C. H. Harper; E. Adamson; and I. E. Lester. The general arrangements were in charge of Thos. Vickers, secretary, British Cast Iron Research association.

Mr. Penton proposed the toast to the King, and the toast to the President of the United States was proposed by the chairman, Prof. Turner.

Discusses Labor Problems

In introducing the guest of the evening, Sir William Bowater referred to the industrial crisis through which Great Britain is passing at the present time. What is needed, he said, is a kind of social armistice. No class can be independent of all the other classes. He urged that the trade unions in Great Britain could profitably pay more attention to the improvement of technical craftsmanship among their members. This, in the opinion of Sir William, would solve a large share of the wage problem automatically. He also advanced the thought that Great Britain would emerge triumphantly from her present difficulties, as she had many times in the past overcome much more serious crises. In conclusion he paid a tribute to the American practice of making extensive use of labor-saving machinery in order to increase production and reduce costs.

In his response, Mr. Penton, after referring to the extraordinary warmth of his reception in England, said he reciprocated Sir William's feelings with respect to the future of Great Britain and the British Empire.

"No one," he said, "could spend even a short time in this great country, viewing even superficially its marvelous industrial organization, without appreciation of its great abilities and conviction as to the leading part Great Britain is destined to play in the future of the world, in both the political and industrial arenas."

He commented also on the geographical position of Great Britain, which, he said, makes it inevitable that she should play a leading part in the world's trade, and referred to the evidences of great industrial prosperity which are visible on all sides in spite of the terrific labor struggle which has been going on in the coal mining industry.

Mr. Penton reviewed briefly the history of the American Malleable Castings association, and told how co-operative effort has resulted in greatly improving the quality of malleable castings produced throughout the United States.

Turning again to general industrial conditions, Mr. Penton referred to Great Britain's remarkable recovery in the iron and steel export trade since the war, pointing out that whereas in 1918 her exports of iron and steel were only 1,600,000 tons, in 1920 they had increased to 3,300,000 tons and are still going forward at a good pace. In concluding his remarks he made an earnest appeal for the promotion of cordial relations between Great Britain and the United States.

On the day following his visit to Birmingham, which included a large number of plant inspections and trips to points of historic interest, Mr. Penton was entertained by the Coventry branch of the Institution of British Foundrymen. Several large works were visited and luncheon was served at the country home of E. M. Iliffe, president of the Coventry Chamber of Commerce. Among those present were: E. Carey Hill, Rowland Hill & Sons Ltd.; W. A. Oubridge, British Piston Ring Co.; J. D. Siddeley, Armstrong-Siddeley Motor Co.; Andrew Harley, Daimler Motor Co., Ltd.; E. M. C. Instone, Daimler Motor Co. Ltd.; J. K. Starley, Rover Motor Co. Ltd.; F. J. Cook, Rudge & Little Ltd., West Bromwick; and Frank Somers, Walter Somers, Ltd., Halesowen.

The New York office of the Iron Trade Products Co., Pittsburgh, has been removed from 1714 at 30 Church street, to 1416-30 Church street, the latter being the Cortland building of the Hudson Terminal

Checking Troubles in Steel Castings

Proper Pouring, Gating and Feeding Are Important Points in Producing High Class Steel Castings—War Needs Advanced the Industry

BY R. B. FARQUHAR JR.

ONLY when the general principles underlying the handling of molten metal are understood clearly can satisfactory results be accomplished and the making of steel castings be reduced to something approaching an exact science. When

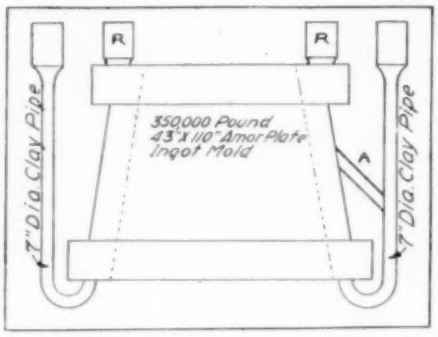


FIG. 1—LARGE MOLD FOR ARMOR PLATE INGOT

these principles are not understood and applied, trouble is sure to be encountered, and producing steel castings becomes merely a haphazard rule of thumb practice. Under present conditions, foundries wherein guess work and *trust to luck* methods prevail cannot survive. Undoubtedly there still are many foundrymen who do not recognize nor understand that many of these problems exist; hence, they cannot accomplish their solution. There are others who do understand them but do not apply a solution. There are still others who do generally recognize the existence of many of these nice problems, and who have encompassed their successful solution by the consistent application of scientific knowledge. To the latter class only will belong the spoils of victory in the future.

Volumes easily might be written on the many types of ladles used, and the methods of transferring the metal from the spout of the furnace to the mold, but it is the purpose of the author only to summarize briefly these types, and refer casually to ladles and ladle practice.

Abstracted from a paper presented at the Columbus meeting of the American Foundrymen's association. The author, R. B. Farquhar, is connected with the Electric Steel Co. of Indiana.

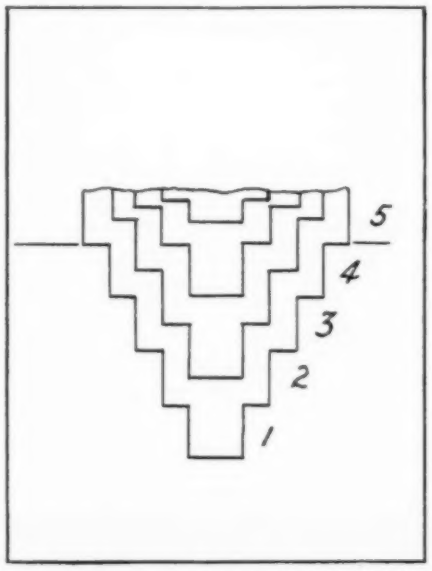


FIG. 2—DISPOSITION OF SECTIONS FOR PERFECT FEEDING

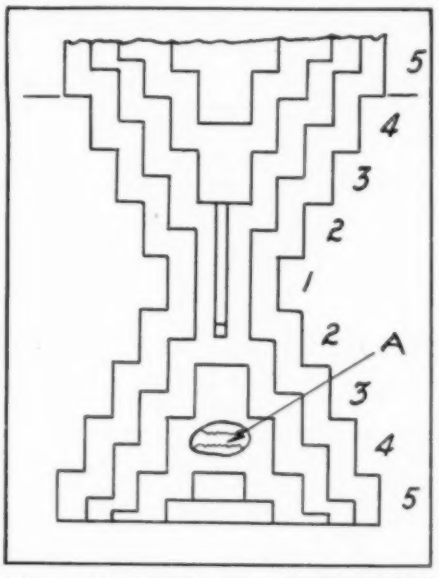


FIG. 3—CONDITION IN CASTING WHICH WILL NOT FEED PERFECTLY—A CAVITY WILL FORM AT A

Bottom pour ladles almost universally are used where large volumes of metal are handled, although many such ladles are used where heats as small as 3 tons are run. For large open-hearth castings, bottom pouring prevails whether the furnaces are acid or basic lined. Bottom-pour ladles are used almose exclusively in pouring basic metal from electric furnaces even though the heat may weigh only 2 or 3 tons on account of the great difficulty in skimming thoroughly the powdery carbide slag from lip, teapot or bull ladles. Among the advantages of bottom pouring it may be mentioned that the coating of slag which covers the metal acts as a protection from drafts and from hasty chilling, and on account of the stream being drawn from the bottom of the ladle through the nozzle, the entrained slag permeating the bath of metal just tapped is constantly rising to its surface away from the exit. Thus the metal will remain hot much longer, and far less slag is drawn into the mold, and particles of slag which rise to the surface after skimming lip-pour ladles are not nearly so prevalent in the castings but this method has difficulties.

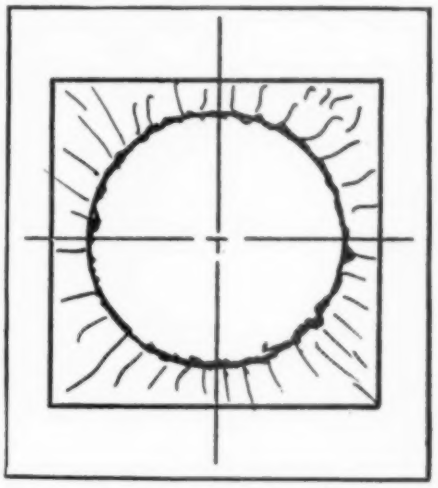


FIG. 4—CROSS SECTION OF SQUARE RISER

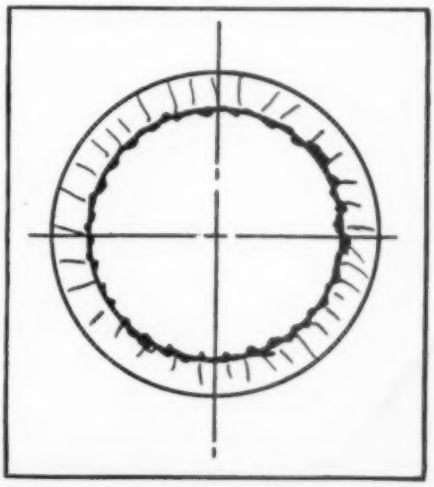


FIG. 5—CROSS SECTION OF A CYLINDRICAL RISER

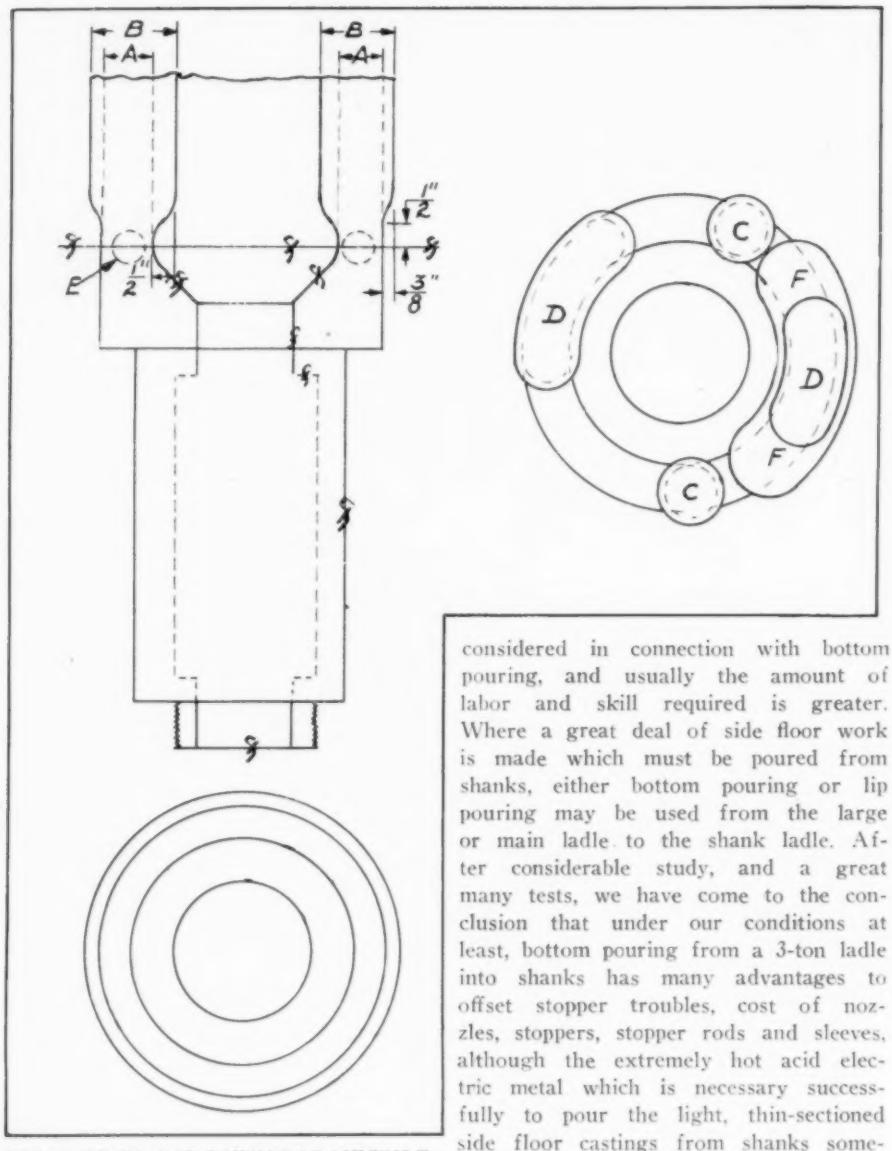


FIG. 6—RISER FOR DUMMY PROJECTILE TO GIVE MACHINING PERFECTION

The common troubles with nozzles and stoppers cutting out, leaking or breaking are often cited as serious disadvantages against bottom pouring. These troubles are real, but generally they can be eliminated by careful study, by experience, and by assiduous attention to the most minute details. I have seen abominable bottom pour ladle practice in large shops which had been in operation for decades because of the failure of those in charge to really get to the bottom of the troubles. I also have seen in more than one newly established shop, these bottom pouring troubles entirely eliminated due to the experience of the man in charge and his persistent and critical attention to the subject. Every time a leaky stopper or other stopper trouble occurred, he sought an exact diagnosis of the cause and spared no expense to prevent a recurrence.

The additional cost of stoppers, nozzles, stopper rods and sleeves must be considered in connection with bottom pouring, and usually the amount of labor and skill required is greater. Where a great deal of side floor work is made which must be poured from shanks, either bottom pouring or lip pouring may be used from the large or main ladle to the shank ladle. After considerable study, and a great many tests, we have come to the conclusion that under our conditions at least, bottom pouring from a 3-ton ladle into shanks has many advantages to offset stopper troubles, cost of nozzles, stoppers, stopper rods and sleeves, although the extremely hot acid electric metal which is necessary successfully to pour the light, thin-sectioned side floor castings from shanks sometimes causes an actual fusion of the stopper rods. By using bottom-pour ladles into shanks, the metal stays hot longer, is freer from slag, there is no labor involved in skimming the large ladle, thinner castings may be expected, and less skull in ladles and shanks. A thorough trial of shanking side floor work from lip, teapot and bottom pour ladles has resulted in the adoption of the bottom pour method for hot electric steel as our present standard practice.

Using Lip Ladles

Lip ladles larger than 4 or 5 tons, due to the weight of the metal involved, are not commonly used. For heats of this size, they usually are used only for converter and electric steel of high temperature. Lip pouring, so far as the writer is aware, practically never is done with large quantities of open-hearth metal, due to the rapidity with which the metal chills after skimming, thus losing its fluidity and causing bad ladle skulls and misrun castings. With hot converter metal or acid electric steel, lip pouring is perhaps most common due to the high temperatures prevailing, extreme fluidity of converter steel, and the comparative ease with which the most of the slags can be removed from the surface of the metal. Due to its high temperature, it is quite common in handling converter metal to hold ladles from 5 to 10 minutes after skimming the slag off before pouring castings if the latter are heavy or of thick sections. This holding not only is highly desirable, but if tested work is being made it is necessary to give the slag time to float to the surface, the entire bath being permeated with the finely divided slag particles incident to the converter process. When converter metal is given this holding period, which is merely a part of good converter practice, it will be found to meet all physical tests expected of it. When pouring such metal from the lip, this entrained slag constantly is rising

FIG. 7—SIMPLE FEEDING OF GEAR BLANKS

to the point from which the stream is drawn instead of away from such point as is the case in bottom pouring. This difference inevitably shows up in the quality of the castings poured by the two methods when physical tests are applied.

The use of teapot ladles is quite common in handling converter or electric metal, and most of the objections to lip pouring are overcome insofar as slag is concerned whether acid or basic.

FIG. 8—THIN WALLED CASTING WHICH REQUIRES SMALL RISERS

DETERMINATION OF CARBON BY THE DIRECT-COMBUSTION METHOD

The method of direct combustion of the metal in oxygen is recommended, the carbon dioxide obtained being absorbed in barium-hydroxide solution, the precipitated barium carbonate filtered off, washed, dissolved in a measured excess of hydrochloric acid and the excess titrated against standard alkali.

The use of potassium-hydroxide solution or soda lime for the absorption of carbon dioxide, with suitable purifying train following the furnace, is recognized as being capable of very satisfactory refinement and as possessing merit where the time element is of prime significance.

Owing to the diversity of apparatus by which correct results may be obtained in the determination of carbon, the recommendations are intended more to indicate what is acceptable than to prescribe definitely what shall be used.

Apparatus

Purifying Train—The method employed eliminates the necessity of a purifying train following the furnace, inasmuch as no precautions are necessary to prevent access of water vapor, or sulphur trioxide—the impurities usually guarded against—from the absorbing apparatus. All that is needed is a calcium-chloride tower filled with stick sodium hydroxide placed before the furnace, or between the furnace and catalyzer, if, as recommended, the latter is used for the purpose of oxidizing organic matter in the oxygen.

Material for Lining Boats—Alundum, "RR Alundum, alkali-free, specially prepared for carbon determination," as supplied by dealers is suitable, and is recommended. The 90-mesh or finer grades are used. Chromite, properly sized and freed from materials causing a blank, may also be employed. No substance containing alkali or alkaline earth metals, or carbon as carbonates or in other form, should be used as a lining material. Quartz sand, owing to its liability to fuse or to slag with the oxides of iron, causing bubbles of gas to be enclosed, is objectionable. Aluminum oxide, made by calcining alum or otherwise, often contains sulphate not easily destroyed, or may contain objectionable substances of an alkaline nature.

Catalyzers—Suitable catalyzers are copper oxide, platinized quartz or asbestos, or platinum gauze. One of these should be used in the forward part of the combustion apparatus, as well as in the purifying train preceding the combustion tube. Platinized materials sometimes give off volatile substances on heating, and whatever material is used should not be subject to this defect.

Combustion Apparatus—Any apparatus heated by gas or electricity which will bring the sample to a temperature of 950 to 1100 degrees Cent. may be used. Combustion tubes may be porcelain, glazed on one or both sides, quartz or platinum. Quartz is liable to devitrification when used continuously at temperatures above 1000 degrees Cent., and may then become porous. Combustion crucibles of platinum may be heated by blast or by Meker burners.

Adopted as standard by the American Society for Testing Materials, 1914

(Continued on Data Sheet No. 386)

(Continued from Data Sheet No. 385)

Boats or Other Containers of Samples Being Burned—These may be of porcelain, quartz, alundum, clay, platinum, or nickel, and should always receive a lining of granular alundum.

Purifying Train before Combustion Apparatus—This consists of a tower filled with stick sodium hydroxide, preceded by a catalyzer.

The Train after the Combustion Apparatus—This consists merely of the Meyer tube for absorption of the carbon dioxide, protected by a soda-lime tube at the far end. Meyer tubes with 7 to 10 bulbs of 10 to 15-cubic centimeter capacity each, and large bulbs at the ends, having volumes equal to the combined capacity of the small bulbs, have been used and found satisfactory.

Filtering Apparatus—In filtration for accurate work, care should be taken to protect the solution from access of extraneous carbon dioxide. This is accomplished in the apparatus shown in Fig. 1. For work requiring less accuracy, the barium carbonate may be filtered off on a filter made by fitting a carbon funnel with a perforated porcelain disk and filtering by suction. The precipitate is then washed with distilled water from which the carbon dioxide has been removed by boiling.

Reagents

Oxygen—Oxygen of not less than 97 per cent purity is recommended. Endeavor should be made to obtain oxygen which gives no blank, since the correction for or elimination of this is troublesome and uncertain. For the most accurate work, particularly with low-carbon products, such as ingot iron, etc., the blank should be completely eliminated by the use of a catalyzer before the furnace, with a carbon-dioxide absorbent interposed between furnace and catalyzer.

Tenth-Normal Hydrochloric Acid—This may be standardized by any of the accepted methods, or as follows: Twenty cubic centimeters of the approximately N/10 acid is measured out with a pipette, and the silver chloride precipitated by an excess of silver-nitrate solution in a volume of 50 to 60 cubic centimeters. After digesting at 70 to 80 degrees Cent., until the supernatant liquid is clear, the chloride is filtered off on a tared Gooch filter and washed with water containing 2 cubic centimeters of nitric acid per 100 cubic centimeters of water until freed from silver nitrate. After drying to constant weight at 130 degrees Cent., the increase of weight over the original tare is noted and from this weight, corresponding to the silver chloride, the strength of the hydrochloric acid is calculated, after which it is adjusted to the strength prescribed. The standardization should be based upon several concordant determinations using varying amounts of acid.

1 cubic centimeter N/10 HCl = 0.0006 gram carbon

Methyl Orange—Dissolve 0.02 gram in 100 cubic centimeter of hot distilled water and filter.

Tenth-Normal Sodium-Hydroxide Solution—This is standardized against the hydrochloric acid. Methyl orange is used as the indicator. The sodium-hydroxide solution should be stored in a large bottle from which it may be driven out by air pressure, protecting against carbon dioxide by soda-lime tubes.

(Continued on Data Sheet No. 387)

THE FOUNDRY DATA SHEET, JUNE 15, 1921

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note book form.

The protective covering of the slag previously referred to is present and since the stream is drawn from the bottom of the bath, the slag is rising away from the exit and castings free from slag particles may be expected. However, teapot ladles will give trouble by the spouts freezing up before pouring is completed unless the metal is hot as is commonly the case in converter and electric steel shops manufacturing small, thin-sectioned castings. Great care and haste must be exercised if heavy skulls and high labor costs for chipping are to be prevented and frequent relining of spouts avoided. Even with teapot ladles, skimming in the spout is often necessary due to the constant accumulation of slag around the surface of the spout.

Small bull ladles of 1000 to 2000-pound capacity are common in electric and converter steel foundries. They are filled from a main ladle containing the whole heat, or in some cases, from the spout of the furnace or the mouth of the converter. On account of being small, they are much easier to skim thoroughly, and can be used in pouring small molds close to the floor without serious skulls remaining in them if the metal is hot. They may be used many times without relining or chipping.

The pouring problem involves the size of the mold or volume of metal; the temperature of the metal in the ladle; and the time necessary to transfer the metal from the ladle to the mold to get the best results. Therefore, volume, temperature and time are the prime factors.

For a given volume of a certain temperature, the time required to make the transfer to accomplish the best results may vary greatly for different castings. By this it is meant that some castings weighing 2000 pounds should be poured much more rapidly than others of the same weight due to their shape, area or section. Furthermore, of two castings weighing 2000 pounds each, one might require much hotter metal than the other due to its shape, area or section. The right amount of elapsed time in the transfer from ladle to mold generally can be determined only by judgment or experience, and since it depends upon so many factors, often the only way to find out this time is by the costly method of a test or tryout, often at the expense of a lost casting. With large castings, this of course is expensive and must be avoided, and it is to be regretted that there are no laws, so far as the author is aware, which can be laid down and absolutely applied for the guidance of the foreman upon whom the responsibility rests for obtaining perfect castings. Actual elapsed time for pouring different castings from the largest to the smallest may vary from a few seconds to as much as 25 minutes in exceptionally large pieces. The latter extreme time was found necessary to pour some steel castings that weighed over 300,000 pounds each. Four open-hearth ladles pouring simultaneously through three 5-inch diameter brick runners were required

Table I

Time Required to Pour Large Steel Castings

Ladle	Pounds	No. 1 Runner	No. 2 Runner
A	135,000	1:28 to 1:34 p. m.	
B	135,000		1:29 to 1:35 p. m.
C	45,000	1:34 to 1:37 p. m.	
D	45,000		1:35 to 1:38 p. m.
Total	360,000	Elapsed time—	1:28 to 1:38 p. m.
Excess left in Ladle "D," 5 per cent	18,000	10 minutes to pour	
	342,000		
Added	5,000	Feed at 2:08 p. m.	
Added	3,000	Feed at 3:30 p. m.	
Total weight	350,000	Molten, 2 hours, 2 minutes.	

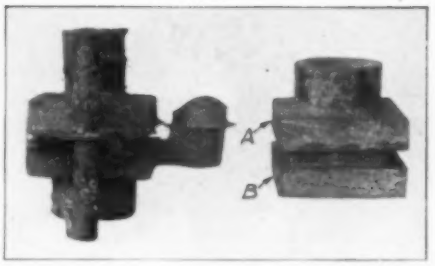


FIG. 10—TOOL POST CASTING GATED FOR MINIMUM DISCARD

Producing Large Steel Castings

Probably the largest steel castings ever produced in this country are the ones referred to. They weighed between 350,000 and 400,000 pounds each and required about 90,000 pounds of feed metal as much as one and one-half hours after pouring. The risers did not solidify until three and a half hours after pouring. The copes were not stripped off these castings until 24 hours

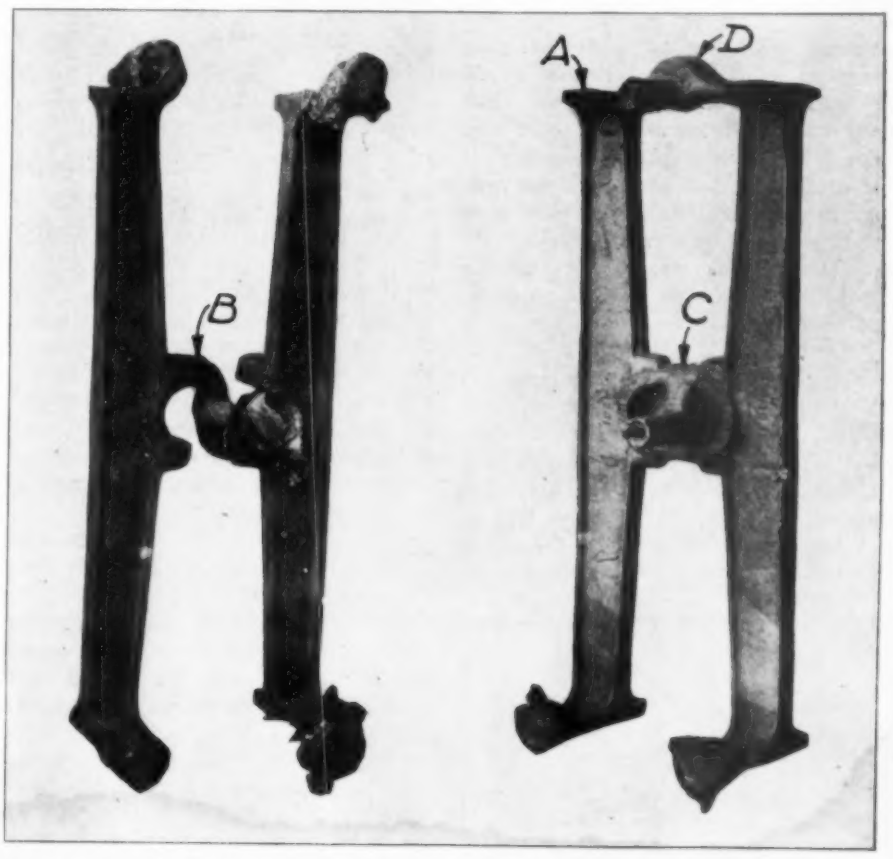


FIG. 9—WHEN POURED AT *B* THESE CASTINGS DID NOT CRACK NOR SHOW SIGNS OF SHRINKAGE

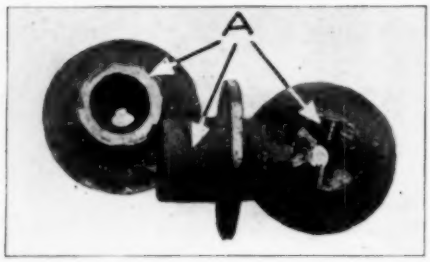


FIG. 11—HUB CASTING OF THICK SECTION

after pouring, and the annealing treatment took about 10 days.

Actual pouring time, taken from the author's notes, of the large armor plate mold shown in Fig. 1, is as shown in Table I.

The vents in the large cores of these castings retained their color 10 days after they were poured, and these castings were not stripped until the fourteenth day after pouring, at which time they showed a dull red color.

Pouring Small Molds

When pouring small side floor or snap flasks from shanks it usually is necessary to get the metal into the molds in the shortest possible time and at the highest practicable temperature in order that it will run up and completely fill all portions of the piece. If a few seconds are lost in pouring such small castings, a misrun job may result. For light, thin sections the high temperature of the metal is no detriment for since it solidifies so rapidly it will not burn into the sand and cause difficulty in cleaning as would be the case with large castings poured too hot. If the area is not too great, and the casting is properly gated, the high temperature should not cause cracks. On the other hand, many large castings should be poured as cool as possible, and hence as slowly as the temperature of the metal will permit and yet take completely and fully the impression of the molds. Also, when poured cold and slowly, the metal will not burn into the sand so much, and there is less liability to check or crack. Just as the rapid pouring of ingots with metal that is too hot, frequently may be the cause of cracks, so may similar conditions be the cause of cracked castings. The author has seen cast steel cylinders practically 10 inches outside diameter and 6 inches inside diameter by 58 inches long crack badly when poured fast with hot metal from the first part of the heat, when the same cylinder showed no sign of cracks when poured slowly at the end of the heat with cooler metal.

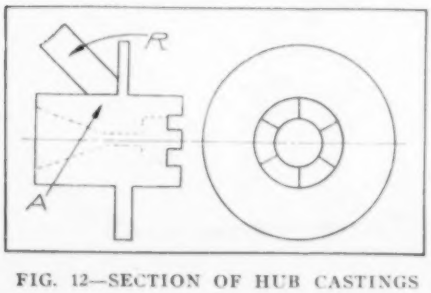


FIG. 12—SECTION OF HUB CASTINGS

Temperature Tests of Molten Metal

Since the rate of pouring a given casting should be arrived at partly by a knowledge of the temperature of the metal at the time of pouring, it is quite important that the approximate temperature should be determined and made known to the man in charge. By the use of a spoon test for temperature, immediately prior to tapping, an accurate estimate of the condition of the metal may be given to the man directing the pouring. In the foundry under the author's supervision, this practice has become established to such an extent that the foundry foreman will give the head melter an order for the metal desired, whether for light floor work or heavy main floor castings, in terms of the number of seconds before solidification of the spoon test. If the heat is ordered for 80 seconds for side floor work and the spoon test shows only 65 seconds, the man directing the pouring expects that he will have many misrun castings on the side floor. We have established the practice of pouring the side floor work with shanks taken from the bottom-pour main ladle containing the whole heat, and if the initial temperature is not as high as desired, part of the side floor may be poured from shanks and the remainder of the metal in the main ladle be bottom poured into heavy main floor work. It is the author's opinion that not nearly as much attention is paid to metal temperatures and pouring conditions by the average foundry foreman as the subject deserves, and as a result, the percentage of defective castings, where much small work is involved, is much greater than might be the case were this important phase given more critical attention and intelligent study.

The most desirable elapsed time in which to pour a given mold may vary from a few seconds for snaps to 25 minutes in the case of the large casting briefly described. An infinite number and variety of exceptions arise that require study, ripe experience and often keen judgment. Even though the temperature of the metal is fairly well known, the man in charge must estimate how long he can keep it in the best condition to pour the molds of a given heat, and it will be necessary to select the order in which the various castings should be poured according to their comparative weight, area and section, as well as their intricacy, liability to crack, check, etc. There is a nice balance to be determined, a great many factors are involved, and perfection of accomplishment is forever just out of reach.

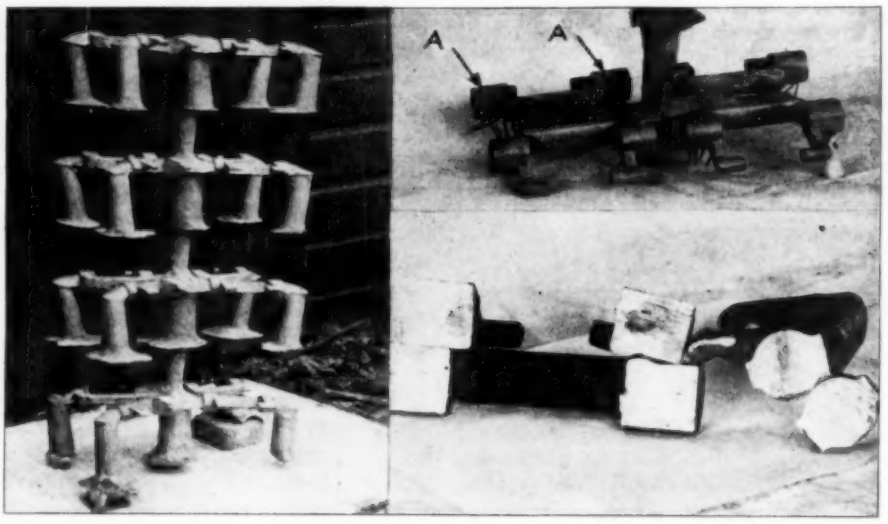


FIG. 13—SMALL CASTINGS WITH GATES AND RISERS OPPOSITE FIG. 14—BETTER METHOD OF GATING CASTINGS SHOWN FIG. 15—SOLID METAL OBTAINED BY GATING SHOWN IN FIG. 14

Principles of Gating

The speed or rapidity of transferring the metal from the ladle to the molds is controlled by the size of the runners and gates, and these must be determined for large castings from a knowledge of the laws governing the flow of liquids with given heads. The most desirable time in which to fill a given mold of large volume is much a matter of judgment and experience based on the factors already mentioned such as sec-

tion, area and total volume. The gates of various castings may vary from a fraction of a square inch in cross section to as high as two 7-inch diameter clay pipe runners with an aggregate section of 77 square inches for large molds. Gates may be single, double or multiple, and in large castings, the gate may be what is known as *straight* height as is indicated in Fig. I at *A*. This runner *A* half way up the large mold weighing 350,000 pounds is highly desirable, since it will permit the hot metal to enter over the surface of the mold at that point at a time when the The entrance of hot metal at *A* will thus make a smoother casting, and will run up better from *A* to the top of the casting, Fig. I. It will also permit the metal at the bottom of the casting to begin to cool ahead of the metal at its top from which point feed is drawn.

The gates on small castings may be Y-shaped, fan, horn or strainght, according to the design of the casting involved. They must be so arranged

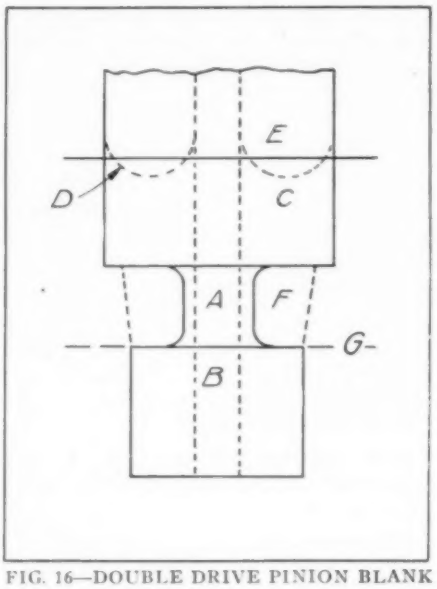


FIG. 16—DOUBLE DRIVE PINION BLANK

that they will not cut, wash nor trap air. Gates should be placed so that they will introduce the metal into the mold at the spot least likely to cause cutting or disturbance of cores or sides of mold; objects not always easy of accomplishment. Consideration must be given to liability to hot or cold cracks upon solidification of the metal and the cooling and shrinking of the casting. In locating gates attention also must be paid to feasibility of their removal in the cleaning department with the greatest ease and least expense. Oftentimes gates may be designed and used as feeders for small and medium sized castings (see Figs. 14 and 21) and occasionally feeders or risers may be used for pouring, thus eliminating the necessity for other runners and gates.

The successful feeding of castings

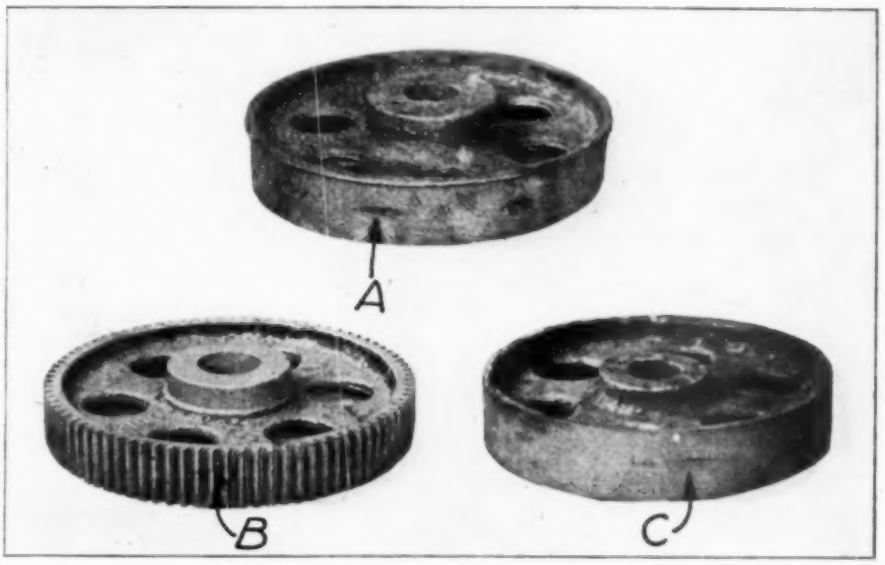


FIG. 17—THESE CASTINGS INVOLVE SHRINKAGE PROBLEMS

only can be accomplished by a thorough knowledge of the physical laws which govern the solidification of different masses of molten metal. The study of relative masses adjacent to each other is of fundamental importance. Again it is found, as in the case of pouring already explained, that the factors of volume, temperature and time are the ones to be considered. These physical laws, in the opinion of the author, may be briefly summarized somewhat as follows:

1—Two equal masses of molten metal of the same temperatures and approximately the same area will solidify at the same time providing the containers or molds are of relatively the same radiating and conducting power.

2—Of two equal masses of molten metal, the one with the higher temperature will solidify after the one of lower temperature. The former will require more feeding after it has been poured, all other factors such as nature of container, chills, etc., being equal, because the one of higher temperature has a far greater drop to the solidification point, and it will require more feed after being poured at such higher temperature due to its lower specific gravity or conversely due to its greater volume per pound; hence its greater shrinkage in passing from its higher temperature to the temperature of solidification.

3—Of two equal volumes of molten metal of equal initial temperatures, the one with the greater area per pound of weight will solidify first because of the greater surface exposed to the conducting and radiating effect of its container.

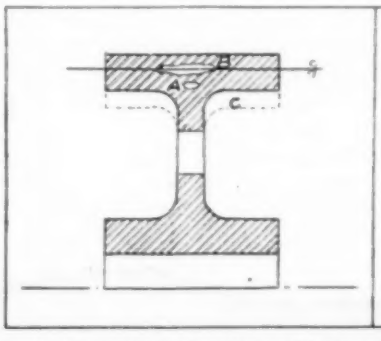
4—Of two castings of unequal volume, the one of smaller volume will solidify first provided the approximate areas and temperatures are the same, and the radiation through the containers are equal.

5—Of two castings of the same initial temperature, of the same area but of unequal volume, the one of greater volume may solidify before the one of lesser volume through the introduction of artificial means such as "chills" to accelerate the cooling of the larger.

6—The percentage of metal to feed two castings of the same volume may vary greatly if such castings are of radically different area and different section, the one with the greater area and thinner section requiring less feed after pouring but before solidification than the former.

The distinction should be borne in mind between the amount of metal required to feed a casting to get it perfectly solid throughout and the amount of riser or top discard remaining after solidification. The one may differ widely from the other, for by perfect feeding, the amount of actual riser or top discard remaining after solidification may be greatly reduced if feeding conditions are well balanced.

Referring to the first law, the introduction of chills may be used to accelerate the cooling and hasten the solidification of the one mass or the other as may be desired. In regard to the second law, the writer frequently has seen many striking examples of this con-



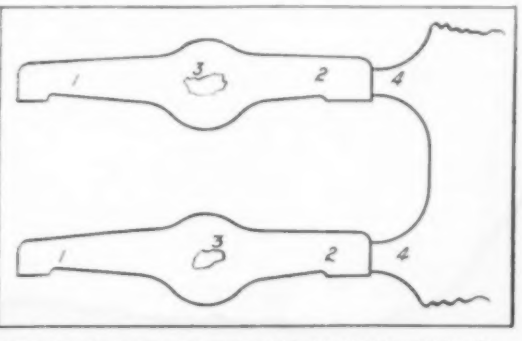


FIG. 18—SECTION SHOWING SHRINKAGE CAVITIES IN GEAR BLANKS FIG. 19—ROCKER ARM CASTING WHICH SHOWED SHRINKAGE AT 3 WHEN GATED AT POINTS MARKED 4

dition in pouring large castings. Extreme cases have been noted in pouring ingot molds weighing from 150,000 to 350,000 pounds each. He has seen such castings when poured hot require from 15,000 to 25,000 pounds more of feed metal after the mold was originally filled, and before solidification than the same castings required when poured with cool iron. In each case the weight of the remaining riser or top discard after the castings had become cool may be the same, but the amount of feed metal required to make the casting solid differed tremendously. He has seen the same difference prevailing in pouring large steel castings.

Referring to third law mentioned, a casting such as is shown in Fig. 8 will solidify much quicker than the casting shown in Fig. 10, even though their weights be about the same because of the much greater radiating surface of

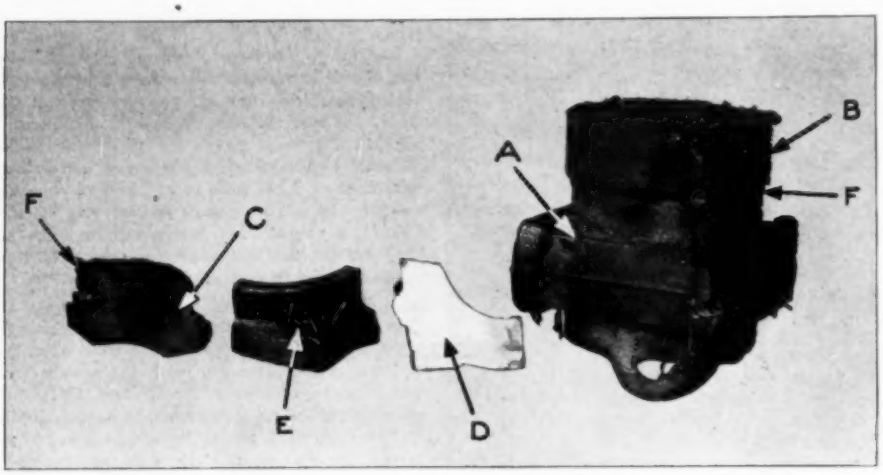


FIG. 20—METHOD OF GATING SOME SMALL CRANK PIN BOXES

the mold and the greater area over which the molten metal is quickly distributed and chilled. Theoretically, these two castings might be expected to require the same amount of feed, and perhaps they do, but the molten metal of casting shown in Fig. 8 is shrinking rapidly while pouring and when solidification has taken place, the actual amount of top riser or discard remaining is only about 10 or 15 per cent, whereas in the case of Fig. 10, the molten metal in the mold is much longer in solidifying after having been poured and hence a much larger riser or reservoir from which to draw feed as it cools will be required, and the amount of top discard remaining may be as much as 30 or 40 per cent. However, another condition prevailing in castings such as Fig. 8, should not be overlooked. Where thin and thick sections are adjacent, it is possible that certain thin sections may shut off some adjacent thick sections from feed; hence, such adjacent thick sections will have shrinkage holes that canot be fed. A casting in which such a condition prevails will lack the density possessed by a casting that has been perfectly fed in all portions, as shown in Fig. 10.

Referring to the fourth law: If the area of the heavier casting is far greater than that of the lighter, it is quite possible that the former may require a much smaller percentage of feed for its weight than the latter because of the accelerated cooling of the heavier casting due to its radiating surface. For example, the casting in Fig. 8, although much heavier than the gear blank shown in Fig. 7, undoubtedly will solidify throughout sooner than the gear blank although the latter is much lighter than the former.

The fifth law in fundamental and constantly must be borne in mind in feeding castings. Undoubtedly, in the majority of castings there are certain thick sections that are inaccessible and hence lack solidity unless their cooling is accelerated by artificial means. Reference to Figs. 11, 12, 14, 16 and 19 will show examples of such sections. Many such thick sections either will possess shrinkage cavities or must be artificially chilled if they cannot be fed directly as was done for example to feed, and which will solidify after other thinner sections, in the case of the bottom flange *A* of Fig. 10 with a lump feeder.

Referring to the sixth law, the actual top discard by the free use of chills may be reduced and actual shrinkage cavities and lack of density in thick sections may be prevented. Years ago the well known practice of some steel foundrymen of reducing the size of risers and *necking* them so that the castings would appear solid under the riser and yet would be hollow inside was the cause of much jovial comment on the part of some of their competitors, and so far as the author is aware this practice is not tolerated in these days. The frequent use of chills in our own foundry has reduced the percentage of top scrap by as much as 5 or 6 per cent and increased the amount of weight going out over the scales in proportion, not to mention the decreased weight of castings returned.

Feeding Large Steel Castings

In feeding large castings, the use of charcoal, soapstone, sawdust and other such substances on the top of large risers assists in feeding by retarding the freezing up or solidification of the riser. By the manful use of iron rods pumped up and down in risers of heavy castings, feeding may be assisted, the riser neck thus be kept open, and the metal prevented from freezing before it settles into the mold. The use of feeding rods in the hands of a strong-armed laborer or molder is of great assistance in feeding both iron and steel castings of large size which may take many minutes to solidify throughout.

The percentage of top discard to the weight of castings may vary greatly for different classes of castings and in different shops. In small gated castings, the weight of gates, runners and risers may be 200 or 300 per cent of the weight of the casting. In much heavier castings, the weight of the risers may vary from 8 or 10 per cent of the weight of the casting all the way to 50 per cent. How to determine accurately the correct amount of riser necessary to feed given castings often is quite a problem, but usually it can be satisfactorily solved by study and experience, leaving of course a safe margin of allowance for variation of pouring temperature and other factors not admitting of accurate measurement or control. The percentage of riser provided too often is neglected, and not given the attention required, frequently being left to the molder or to the guesswork or rule of thumb methods of the foundry foreman or patternmaker. A thorough understanding of the physical laws, which the author has stated in general terms, is necessary for the successful feeding of castings, and yet these rules often are understood only partially and frequently poorly applied, if at all, by foundry foremen. Too often no careful study is given to these problems which are of such vital importance and mean so much in the reduction of foundry costs and maintaenance of foundry reputations. Fig. 2 represents graphically the ideal disposition of sections to accomplish perfect feeding and solidity. This casting when poured in the position shown in Fig. 2, will be solid in all portions below the top discard, and its several sections will solidify in the order of the numbers indicated, that is, 1, 2, 3, 4, 5, the top scrap solidifying last and containing all of the shrinkage.

Fig. 3 illustrates graphically the conditions which prevail in a casting that does not feed perfectly and hence possesses a decided shrinkage cavity at *A*. The casting poured in the position of Fig. 3 will be solid in its upper half which will solidify as indicated by the numbers, but the lower half will be shut off from the source of feed by the solidification of the central sections, 1 and 2, forming the shrinkage cavity at point *A*. If these illustrations are kept clearly in mind and the various sections of different castings adjacent to each other are analyzed in the light of these two figures, much shrinkage trouble may be prevented. While the central portions 1, 2, 2, etc., of Fig. 3 will solidify and cut off feed from the source, it must always be borne in mind that by artificial means the solidification of the lower portions, 3, 4, 5, may be accelerated to such an extent that they would solidify before 1, 2, etc., and hence be fed solid. By a study of Figs. 2 and 3 and the laws previously outlined, the fundamental principles of feeding may be understood and applied. The practical application of these principles to the castings made each day, becomes a most interesting, important and fascinating subject. With the infinite variety of castings that are common today, a certain amount of experience with some of the problems of the past is necessary, and even when such experience is possessed, more or less experiment and demonstration by actual tests is required. Making one or more castings, if they are not too large, gating and feeding them in a way believed to be the best, and then rough turning them or cutting them open to see if they are solid is time well spent, and often may prove one of the best of investments.

The writer always has felt that every casting is largely a law unto itself, and there is nothing so satisfying as to know that you have a casting right before going ahead. The heading and gating of important castings should not be left to the discretion of the molder, nor should it always be left entirely to the foreman in charge, be he ever so capable. The superintendent should be encouraged to call into conference the patternmaker, the foundry foreman, the chief inspector, and often one or more molders in mapping out the way in which certain jobs best can be made, and deciding upon the best method to pursue. Frequently the solution for a most knotty and perplexing problem has been suggested by a molder or patternmaker. When the combined knowledge of all those in charge can be concentrated on a foundry problem, involving these subjects, it is apt to be solved satisfactorily. When a suitable method has been evolved, some routine should be established whereby the decision is recorded and handed down on the records for future reference and benefit. The photographing of such castings, painting of patterns different colors to indicate the location of gates and risers, their size, etc., are valuable aids to foundry operation.

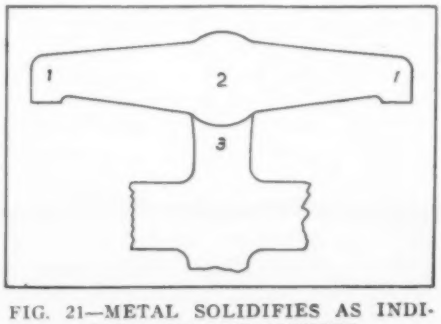


FIG. 21—METAL SOLIDIFIES AS INDICATED BY THE FIGURES

Risers Should Be Cylindrical

Where space will permit, the shape of a riser usually should be a true cylinder, since solidification takes place in a circle as shown in Fig. 5, whether the riser is cylindrical or square as shown in Fig. 4. For this reason the corners of a square riser are largely wasted metal, as indicated in Fig. 4. A square riser, 4 x 4 x 6 inches high contains 96 cubic inches for feed, and a circular riser of the same diameter as a side of the square and the same height, contains 75.4 cubic inches, a saving of 20.6 cubic inches of top discard. The round riser undoubtedly will feed the casting just as effectively as the square riser greater in size. In the author's opinion the most effective height of risers generally has become established as one and a half times their diameter; therefore a 6-inch riser need not be more than 9 inches high, a 12-inch diameter riser more than 18 inches, a 20-inch 30 inches high, etc., to get the maximum result for the minimum expenditure.

Risers may be elliptical, annular or irregularly shaped according to conditions. If it is necessary to make them square or rectangular where they join the casting, they may be necked to cylindrical in shape above that point. Several examples of risers are shown in Fig. 6, which represents a dummy projectile. The specifications called for machined surfaces all over outside and inside and all surfaces had to be free from defects. The best way to make these castings was the subject of a great deal of study, and the best results finally were accomplished by pouring them from the bottom with an annular riser indicated by *BB*. To pour them with the threaded end up would not have given sufficient area for an annular riser at that end, and the thick section of metal at the other end would not be fed unless by the use of a lump riser, which was undesirable. To pour them on the side meant that they would be harder to feed, the riser would be more difficult to remove from the cylindrical surface, and the cope side of the castings would possess some slag or sand holes which would cause their rejection. By referring to the several possible methods, the annular riser method *BB* meant that the cope end of the casting was entirely open, and all dirt would float to the surface, and all parts of the heavy section at the top

FIG. 22—ROLL COUPLING BOX CASTING WITH THICK AND THIN SECTIONS

Table II

Standard Properties of Steel Castings

STANDARD SPECIFICATIONS

	Castings		Forgings	
	A. S. T. M. Hard	U. S. Ordnance, No. 3	A. S. T. M. Annealed	Ordnance No. 3-FS
Tensile strength	85,000	80,000	80,000	90,000
Elastic limit	38,250	36,000	40,000	42,000
Per cent elongation in 2 inches	15.0	15.0	22.0	16.0
Per cent contraction in 2 inches	20.0	20.0	30.0	24.0

ACTUAL TESTS UNALLOYED STEEL CASTINGS—HEAT TREATED

Tensile strength	106,350	100,000	97,500	93,500	92,000	98,500
Elastic limit	70,600	64,300	58,200	52,500	57,000	60,000
Per cent elongation	19.0	20.0	21.0	24.5	24.0	16.0
Per cent contraction	30.7	34.0	32.1	43.1	37.2	27.4

would be thoroughly fed. The use of the risers *CC*, *DD* and *FF*, might accomplish the same results, but not with the same certainty, and they were more difficult to place and remove. The actual percentage of top discard with the annular riser *BB* was more easily controlled and reduced. By making the annular riser the same width as the casting, as indicated by the dotted lines *AA*, insufficient feed was provided and shrinkage holes occurred at *E* below the finished lines.

To show the practical working out of some of the general principles of correct feeding which the author has endeavored to point out, the following

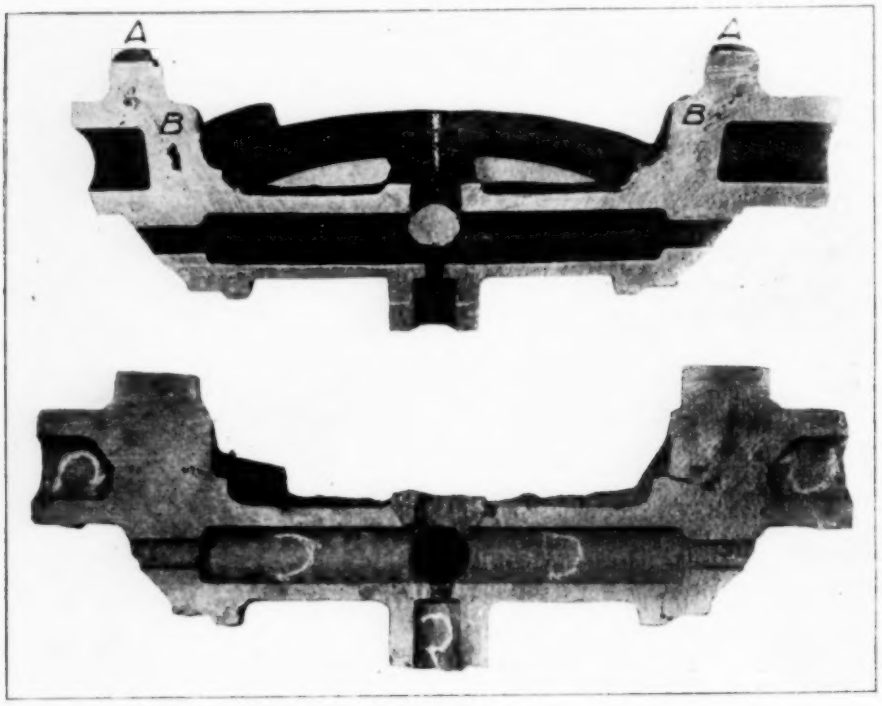


FIG. 23—SAWED SECTIONS OF PINTLE BEARING CASTING—THE UPPER CASTING SHOWS THE DEFECTS WHICH IN THE LOWER ONE HAVE BEEN REMEDIED THROUGH PROPER GATING AND CORING

typical examples may be of some interest.

Fig. 7 illustrates a simple case of adequate feeding of plain gear blanks and Fig. 8 is an example of a casting with thin walls and large area exposed to the mold, causing it to solidify so rapidly that little if any feed is necessary after having been poured. In Fig. 8, the risers are little more than what might be called *flow offs* or *pops* and which only amount to 8 or 10 per cent of the weight of the casting. The gear blanks of Fig. 7 do not weigh nearly as much as the steel flask of Fig. 8, and yet the blanks will solidify later than the flask if poured at the same time and the same initial temperature, and will take far more feed after pouring but before solidification, therefore, have much more top discard. See the fourth law regarding rates of solidification as previously given.

Fig. 10 shows a tool post successfully gated and fed to obtain perfect castings with a minimum of discard. These castings are machined all over, outside and in, and both flanges then are drilled full of holes so that if defects or shrinkage exists they are certain to be brought to light. Fig. 3 illustrates exactly the condition to be met in the casting shown in Fig. 10. In the illustration, the casting to the right with gate and risers removed is inverted when compared with the casting to the left without them removed. The center riser on top of flange *B* to the left will not feed and take care of the lower flange *A* because the neck between the flanges at the center of the casting will solidify first, and shrinkage is sure to occur in the lower flange *A*, hence the *blind* or *lump* riser on the lower flange to feed it. The thickness of these castings is such that it was not found feasible to chill the lower flange *A* sufficiently to cause it to solidify before the neck between the flanges.

The castings shown in Fig. 9, when poured at *D* without top risers on the flanges *A*, naturally showed shrinkage at *A*; when poured through quadruple gate at *C* they cracked near the center adjacent to the gates; when poured at *B* with the gate changed as shown, all ends with top risers, they did not crack nor show shrinkage.

The hub castings indicated by the letter *A* in Fig. 11, and shown in section, Fig. 12, are an example of a thick section which was quite difficult to adequately feed, and too thick to chill. These hubs are machined all over, and perfect solidity and clean surfaces were essential. There is no section thick enough to take a suitable riser that would feed the thick portion *A*, shown in Fig. 12. Therefore, it was necessary to place the riser on the barrel of the casting as indicated at *R* and by tilting the mold slightly, clean and solid castings were obtained, although the removal of the riser was somewhat difficult.

Figs. 13, 14, 15 are examples of pouring and chilling small gated castings. In Fig. 13, the 1-pound pieces were gated on the one end, and had a riser on the other end. Solid castings were obtained by this method, but at an excessive expense for risers. By re-gating these castings at the center, which was the heavier portion, with a gate large enough to feed them as shown in Fig. 14, solid castings were obtained, and the percentage of discard greatly reduced, although chills had to be used in the two end bosses *A*.

The author wishes to disclaim all responsibility for the excessive and incorrect gating exhibited in Fig. 13, and the poor practice, in his opinion of stacking such small work as this, thus making a bad matter worse.

Lightening Recess Causes Trouble

A double-drive pinion blank, Fig. 16, is a casting that may be given a great deal of interesting study, both from the standpoint of quality and workmanship, as well as shop costs. If cast on end as shown, is a three-part job, the pattern having been parted at *G*, but molded in this way, satisfactory production is not possible. Even when cast in the position shown, the lightening recess desired by the customer, as shown in dotted lines *B*, is in the way of placing either a cylindrical or annular riser. The customer objected to filling in this lightening recess although it amounted to only 4 or 5 per cent or the weight of the casting. If cast from a split pattern on its side, two risers on cylindrical surfaces would be necessary, and any dirt or shrinkage would occur in the outside diameter where the teeth are cut. Such risers are expensive to remove. The author personally made up five accurate estimates of the exact cost to produce these blanks cast in five different ways, and found that the best and surest, as well as the cheapest, was to cast them in the position shown, with an annular riser *E* and with the addition of metal indicated by the dotted lines at *F*. This made it a job that could be placed on a molding machine for economic quantity production, all portions of the

casting would be perfectly fed, the castings would be free from floating slag or sand, and the excess metal *F* and the lightening panels *D* could be rough turned out by the foundry before shipment at a lower cost than if made in any other way. Without the addition of the extra metal *F* the lower portion *B* would not be solid unless severely chilled or unless fed with a lump riser which was objectionable for reasons heretofore explained. This casting is a striking illustration of the value and economy of careful and critical analysis of all production jobs, not only with a view of getting the best work, but to getting such results at minimum cost.

The Shrinkage Problem

The gear blanks, Fig. 17, show examples of some rather troublesome shrinkage to overcome by correct feeding. When the teeth were cut in these castings, shrink holes were uncovered at the base of the teeth opposite the intersections of the web and the rim. These shrink holes are shown at *B* in the casting which has had the teeth cut, and at *A* in the casting at the top which was rough turned for examination. These shrink holes also are indicated in the section, Fig. 18, at *B*. To eliminate these shrink holes by six risers at the intersections referred to would be at the expense of an excessive amount of top scrap, and would cause the castings to crack. To cast them on edge with one riser on the outside diameter, would not feed the portions referred to. To cast them on the side with three risers would not feed the three intervening portions or intersections. To chill these portions was not found desirable. Shrinkage holes were prevented by increasing the thickness of the rim of the pattern as shown by the dotted lines at *C*, Fig. 18, the castings being poured on their sides with three risers and without chills. This added metal resulted in a sufficient retardation of the solidification of the rim so that the web at the six points of intersection would be fed from the rim. The rim thus remained fluid longer drawing feed from the three risers to all portions. To check up the correctness of the assumption, the casting to the right in Fig. 17 was rough turned to ¼-inch below the base of each tooth, and all shrinkage had disappeared except the one very small hole shown at *C* to the right in Fig. 17. This hole has been indicated at *A* in Fig. 18. The effect of thickening the rim as indicated at *C*, Fig. 18, was to materially retard its solidification, and if shrinkage appears at all, it will be much reduced in size as shown at *A*, and it will appear below the finished line *F* where it can do no harm. Fig. 20 shows the method finally adopted and probably the most successful one for making large and small crank pin boxes with annular risers *B*. These castings are difficult to make and feed on account of the four heavy sections, *A*, in the triangle formed between the bore of the casting and the square exterior outlines. The castings are machined all over and then are sliced into halves and drilled through the haunches for the necessary bolts to bolt them around the crank pins. The drilling is the last operation, and if shrinkage holes occur at these thick corners, they will not be discovered until after the several expensive machining operations have been completed. Even if small shrinkage holes are found the castings will be rejected. By casting them with an annular riser *B* and by chilling them with heavy nails in the four corners as indicated at *E*, the castings were found to be perfectly solid when cut open, as shown in Fig. 20 at *D*. When the annular riser only was made the thickness of the casting, shrinkage occurred at *C* below the finished lines *F*. Therefore, it was necessary to make the riser about ¾-inch thicker than the hub of the casting; that is, ⅜-inch thicker on each side. When made in this way these castings have been found to be free from defects which would cause rejection, and the shrinkage which was certain to occur at the four thick corners has been eliminated.

The small gated rocker arm castings, Figs. 19 and 21, when gated at 4-4 showed shrinkage at 3, the different sections of the castings solidifying in the order of the figures, namely, 1 first, 2 next, 3 last. In this way the thick central section 3, possessed shrinkage holes because there was no source of feed. By gating these castings to the thick central portions as shown in Fig. 21, with gates sufficiently heavy to provide feed, the order of solidification would be 1-1, 2 and 3, the order desired.

Thick and Thin Sections Adjacent

Fig. 22 is a striking example of thin and thick sections adjacent to each other. The castings must be thoroughly fed or well chilled to get them solid. If risers are put on three of the teeth or thick sections of this coupling box, there are sure to be internal shrink holes in the other three thick sections which are shut off from the source of feed by the previous solidification of the sections between them. This was proved by severely chilling the thick sections between the three risers when this shrinkage was overcome, and the weight of these castings was actually increased about 2 per cent. These castings had previously been failing, and an examination of the fractures under the microscope showed that they had been poorly annealed if at all, and physical test bars cut from the same point showed poor ductility. These castings since have been made of lower carbon and given the double water treatment, and have proved to be extremely tough and very satisfactory.

Risers too Small

Fig. 23 shows sawed up sections of two pintle bearing castings for 3-inch field mounts made in large quantities for the ordnance department of the United States army during the war. The upper casting shows bad shrinkage below the risers *AA* when the bearing cores were made as shown in this illustration. The risers were too small, and the choke points *BB* between them and the thick section at the end of the bearing cores solidified first. Hence the thick sections below *BB* possess shrink holes. By decreasing the depth of the bearing cores and by chamfering off the corners of them and increasing the size of the risers, solid castings were obtained as shown in the lower portion of Fig. 23. The evolution of these castings from the standpoint of pouring, gating and feeding was interesting, the various methods being checked up by cutting open the castings and subjecting them to other tests to make sure that they were sound and satisfactory beyond any doubt.

French Founders Form Important Syndicate

The general meeting of the Syndicate General des Fondeurs en Fer de France has ratified the union of brass, steel, malleable, aluminum, copper and bronze founders. This new move embraces all the elements of the foundry industry of France under one controlling head. Each section of the confederation will have a titular head of its own, who, in each instance, will become a vice president of the general organization. The president of the syndicate will be Monsieur Defour, president of the administration council of the Usines Pied-Selle of Paris. The vice presidents are Monsieur Maxime Plichon, of the cast steel group; M. Rouard, of the copper and bronze section; Monsieur Jeannin of the aluminum section and Monsieur Parent of the malleable section.

Two furnaces recently installed by the Electric Furnace Construction Co., Philadelphia at the plant of C. & J. Weir, Ltd, Glasgow, Scotland, are being operated on Monel metal.

Correcting Flaws in Metals and Mixes

Problems of the Gray-Iron, Malleable and Steel Foundry Discussed

By H. E. Diller

Electric Furnace Melting Recommended

Question.—I want to make a small amount of alloy steel castings of various compositions in my cutlery works in India. It is my intention to melt steel scrap first in an oil-fired furnace and then refine and add the alloys in the electric furnace. About one ton of metal will be required a day and will be made in five or six heats. Do you think the plan of first melting in an oil furnace would be advantageous?

Answer.—We would call to your attention that the object of first melting steel in an open-hearth furnace and refining in an electric furnace is to save expense, but this saving can be accomplished only where large tonnages are involved. Therefore, we do not think you would gain anything by melting your charge first in an oil furnace. We would recommend that you use the electric furnace for the entire process, especially as you have several heats a day and can keep your furnace heated from one charge of metal to the next. Any saving which might appear by using a duplexing process would be slight and certainly would not be enough to pay for the trouble encountered in melting steel in one furnace, transferring it and finishing the refining in another.

Annealing Will Soften Gray Iron Castings

Question—We have a number of castings which come from the foundry too hard to machine. Can you give us any information as to how these castings can be softened?

Answer—The only way to soften your castings would be to heat them in an oven and cool them slowly. Heating to 550 degrees Cent. (1025 degrees Fahr.) will in no way injure the castings and if this will soften them, they should not be heated higher. However, it may be necessary to heat them to 800 degrees Cent. (1475 degrees Fahr.). They should be held at this temperature about an hour after they are thoroughly heated through, after which they should be cooled slowly. This treatment will weaken the iron somewhat and lower its resiliency. We cannot say definitely whether the castings will be softened sufficiently at 550 degrees Cent. as we do not know the composition of the metal or the depth of the chill. With a high-silicon low-sulphur iron having only a slight chill, this temperature would be sufficient to soften the casting for machining. Should the iron contain a low percentage of silicon and a high percentage of sulphur, and the chill be deep, it might be necessary to heat the casting to the higher temperature to soften it.

Production of Piano Plates

Question—We would like to have information in regard to the manufacture of cast-iron piano frames including the composition of metal and the proper kind of sand to be used. We would also like to know what method is used to prevent the casting from warping in the molds.

Answer—Piano-plate castings should be made of a metal which is strong but comparatively soft. For this reason the silicon should range from 2.20 to 2.50 per cent and the phosphorus from 0.4 to 0.5 per cent. Sulphur should be kept below 0.1 per cent and the manganese should be approximately 0.6 per cent. It is of course necessary that this metal be melted carefully without being oxidized and be fluxed with limestone.

A fine sand somewhat similar to the sand used in stove plates is best adapted for piano-plate casting molds. A small amount of sea-coal facing should be mixed with the sand. Castings are prevented from warping by uncovering the center portion of the casting shortly after it is poured. This causes the center of the casting to set first and holds the ends in line.

Keeping Slag from Castings

Question—We are operating a gray-iron stove plate foundry and have considerable trouble with slag in the castings. Would you advise how to overcome this difficulty? Is it practical to use limestone in the cupola?

Answer—Slag in the casting is avoidable by several precautions. In the first place the iron must be melted correctly. If more than five or six charges are used in the heat, 25 to 30 pounds of limestone to a ton of metal should be added on each charge after the first, and omitting the limestone on the last charge. This need not be weighed exactly but the man who charges the furnace can measure how many shovelfuls are required.

When the iron comes from the cupola care must also be exercised to skim the ladle. The iron should also be skimmed as it is poured to prevent slag from entering the mold. Additional precautions are also taken in the way of skim-gate cores consisting of small round flat cores with perforations about ¼-inch in diameter set in the runners. Some foundries also use pieces of perforated tin plate laid over the pouring gate. The object of this is to hold back the metal for a few seconds until a bath is formed in the pouring basin to float the slag.

Cupola Melting Losses

Question—How much loss should we have in melting pig iron in the cupola with machinery scrap.

Answer—The amount of shrinkage on pig iron through the cupola would depend somewhat upon the amount of sand on the pig iron and the method of melting, some foundrymen melting with a higher loss through oxidation than others. We believe you should figure this loss at 5 per cent. It is reported in different foundries to vary from 3½ to 6 per cent.

Two Formulas for Making Sand Matches

Question—We would be pleased to have you furnish a formula for a hard-sand-match mixture.

Answer—There are a number of formulas for making sand matches, one good formula is as follows:

	Parts
Finely sifted gangway sand	89
Finely sifted steel or iron borings	1
Pulverized litharge	3
Boiled linseed oil	7

Mix the sand, borings and litharge when dry, taking care to keep out all molding sand, gravel or water. After thoroughly mixing, add 7 parts boiled linseed oil, and mix to the temper of molding sand. This mixture is rammed hard into the cope match and a bottom

bed is boarded on, and after firmly secured by screws in preference to riddle through a No. 12 sieve. If raw nails.

Another method is to take well burned molding sand from castings that have been cleaned with a wire brush, and linseed is to be used, mix 1 part of litharge to 16 in bulk of sand, then mix in the oil, making the sand as wet as possible, but not sufficiently moist to adhere to the patterns. Mix the mass thoroughly and pass through a ½-inch riddle, rubbing it through with the hand, but not shaking it through. Ram the match frame bed on a board and roll over. After the drag is removed, strengthen all soft rammed parts of the match by building up with the oil sand, then brad all sharp edges and places where the pattern strikes. Next draw the patterns and slick the match all over with a small tool. Touch up the high spots and ragged edges with oil and slick smooth again, then let the match have plenty of time to dry. Should there be any danger of the dropping out, drive nails through the face of the match into the bottom board at intervals, as thought necessary.

Tunnel Castings Requirements Are Large

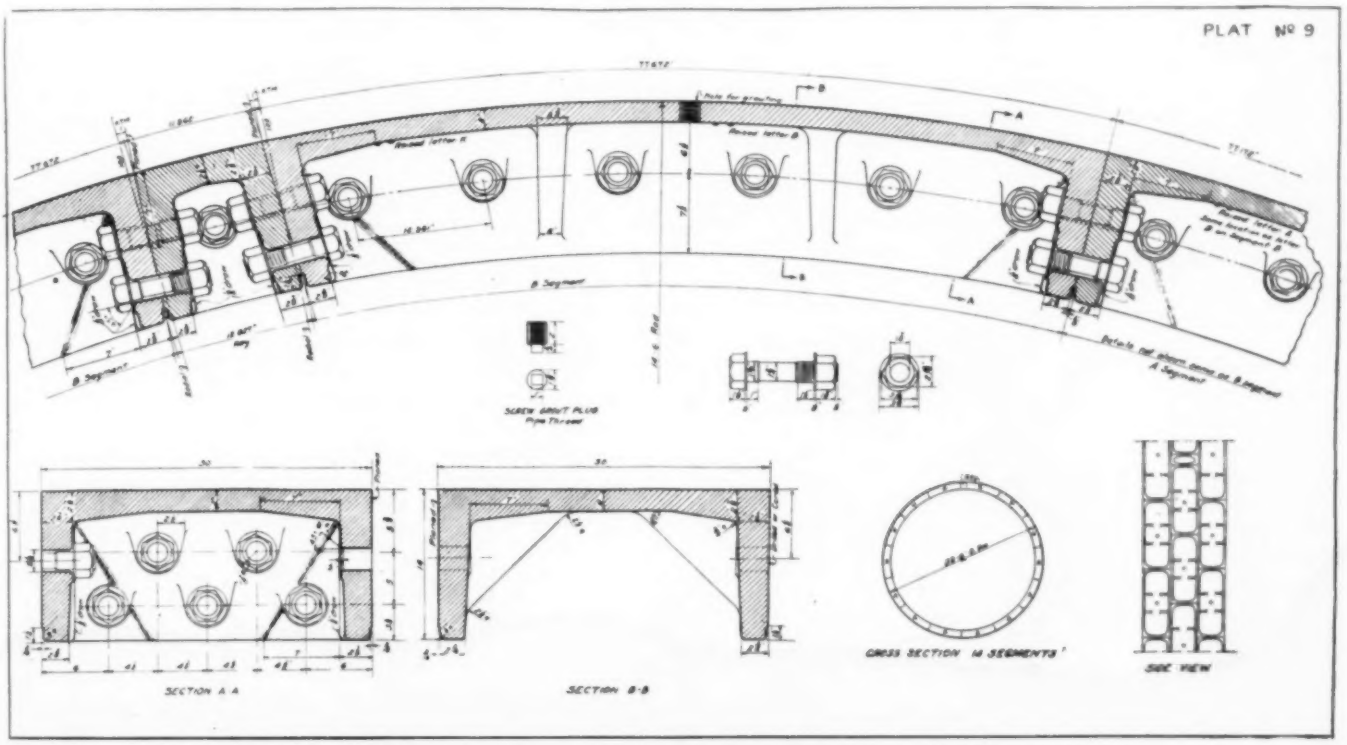
PRELIMINARY estimates show that approximately 115,000 tons of tunnel segment castings will be needed for the New York vehicular tunnel which is to be constructed under the Hudson river, between the island of Manhattan and Jersey City, N. J. These castings are to be of gray iron and as shown in the accompanying drawings, their design is to be practically the same as those used in the construction of existing tunnels in New York harbor. In addition to the segments, numerous other castings will be used in connection with the drainage, ventilation and electric-light systems as well as for other purposes, but while the tonnage will be considerable, it will be only a small fraction of the segment requirements.

In addition to the segments, the principal materials required will be about 4000 tons of 1¼-inch bolts, including washers and nuts. These bolts possibly may be of nickel steel, but this point has not yet been decided. Structural steel will be used for the approaches, shaft and the tunnel to the extent of 12,000 tons. About 3000 tons of reinforcing steel will be required for the approaches and it is possible that concrete will be used in the interior of the tunnel. About 250,000 barrels of cement and 1000 to 2000 tons of cast iron, wrought iron and steel pipe will be utilized. In addition to the principal materials, numerous other materials, such as electric wire, electric appliances, etc., will be required.

Plans for the proposed tunnel and specifications for materials are in charge of C. M. Holland, Room 614, in the Hall of Records, 31 Chambers street, New York. Mr. Holland is chief engineer of the New York state bridge and tunnel commission and chief engineer of the New Jersey interstate bridge and tunnel commission. J. B. Snow is his principal assistant.

Progress in the inauguration of the great project of building the tunnel has been held up for some time by a dispute between the New York and New Jersey commissions. The New Jersey commission holds that the widening of streets at the approach of Jersey City at the New Jersey end of the tunnel constitutes a part fo the work of building the tunnel, while the New York authorities hold that the cost of widening these streets is a matter that should be assessed locally in Jersey city. Recently a plan for terminating the dispute has been agreed upon tentatively and as a result, it is believed, contracts for the proposed work will be advertised for bids within the next couple of months. A few large eastern interests who expect to make an attempt to secure some of the more important contracts, already have requested estimates from makers of bolts and other materials involved in this work.

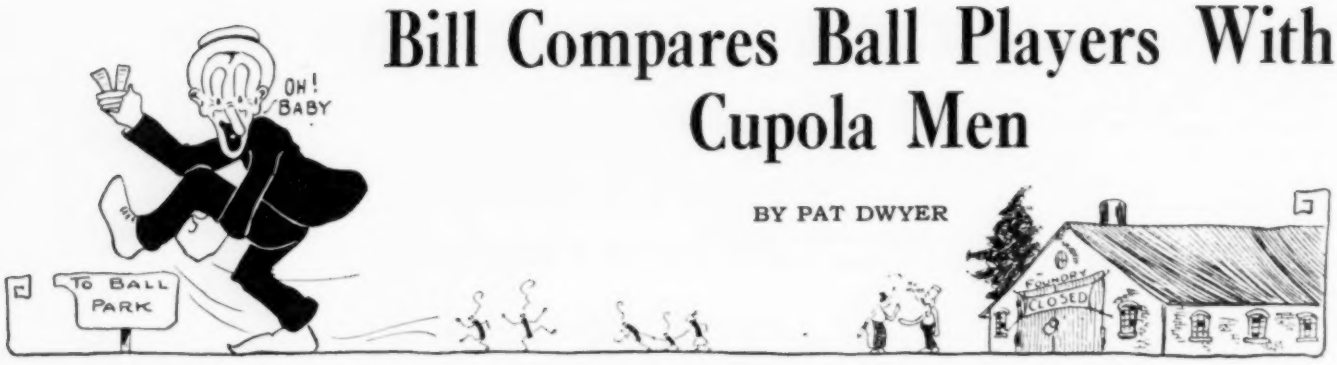
The Jefferson Brass Foundry, Brooklyn, has removed to 62 Delevan St.



DETAILS OF TUNNEL SEGMENT CASTINGS FOR THE NEW YORK VEHICULAR TUNNEL.

Bill Compares Ball Players With Cupola Men

BY PAT DWYER



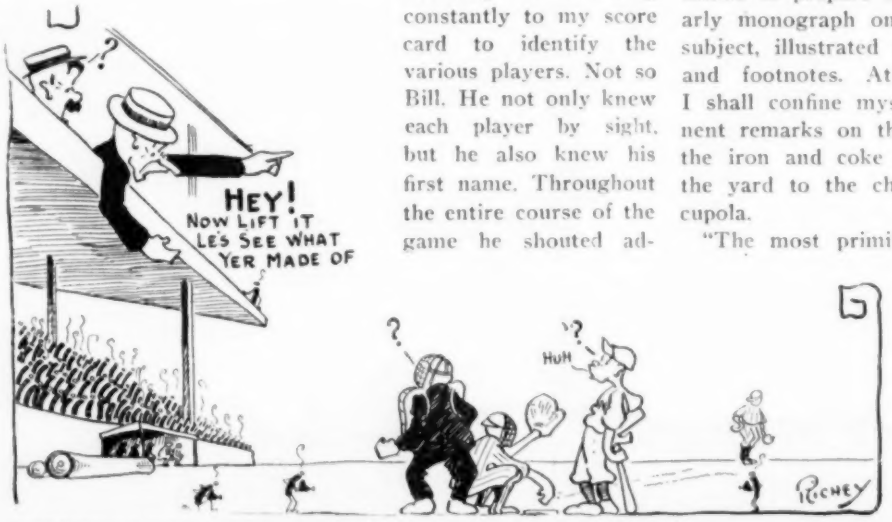
DIVINE Providence which we are told tempers the wind to the shorn lamb and does other little acts of kindness, also provides the compensating feature in periods of business depression similar to the one through which we now are passing with heads bloody but unbowed. This seems to be Bill's philosophy. His shop is only running three and four days a week but instead of sitting around like a lost soul or a Banshee bewailing his sad fate, he rejoices in the fact that he now can attend all the ball games he wants to without having to perjure his soul inventing relatives who could be buried without being missed.

Now I am one of those fortunate or unfortunate people, depending on your point of view, who has to work every day and therefore, I felt undecided for a few minutes one afternoon recently when Bill called in and asked me to accompany him to the arena devoted to our great national game, known I believe among the great army of steady subscribers as the ball yard.

I said that my work was important, the remuneration even more so, several of the children needed new clothes and the wolf came so close to the door at times that his breath was offensive and his long teeth and shining eyes had scared the baby. Bill scoffed at these various arguments and held them up one by one to ridicule. "My dear child," said he, "It is indeed fortunate that I decided to take you with me this afternoon. When a man gets the notion that his work is so important that he cannot leave it for a few hours, it is a sure sign that dry rot has set in. The work went along nicely before you ever squalled your way into the world and it will go along just as satisfactorily after you have been laid away with your toes turned up and with a lily in your hand. You come with me out into the fresh air for a few hours and get the cobwebs blown out of your brain. Get a new perspective and quit worrying about the children's clothes. Oh! ye of little faith. Consider the lilies of the field. They toil not, neither do they spin and yet Solomon in all his glory was not arrayed as one of these. "As for the wolf," he concluded with a grin, "if the worst comes to the worst and he comes too close to the door, why, you can knock him on the head with a hand rammer, drag him in and eat him."

We pushed our way into the grand stand with about 30,000 other enthusiastic citizens and found a couple of choice seats close to the hand rail and looking directly down on the field between third base and the home plate.

While I am familiar with the names of the men on the opposing teams having read them perhaps a million times in the newspapers and heard them discussed perhaps twice that number of times, I never have had the pleasure of meeting one of these athletes personally. I was under the necessity of referring constantly to my score card to identify the various players. Not so Bill. He not only knew each player by sight, but he also knew his first name. Throughout the entire course of the game he shouted advice and encouragement to each member of the home team. He violently applauded every point they scored and loyally maintained a stony silence or else groaned in deep sympathy when the opposition (to drop into the vernacular) pulled a good play.



EXHORTING THE ATHLETE TO SMITE THE BALL EARNESTLY AND WITH VIGOR

After the game I ventured the opinion that chance or luck was an important factor in deciding the final score in a ball game and for a wonder he agreed with me.

"Why, of course," said he, "if it were not for the element of uncertainty the game soon would lose its popularity. If one team won consistently and another as regularly lost no person would go to see the games and besides many of the young men who make a few honest dollars by looking under their pillows would be out of luck. That is one of the reasons why the big leagues always are changing managers and players. However, base ball managers are not the only people who indulge themselves in individual fads and fancies.

Did you ever consider the many methods in vogue for charging a cupola? I don't mean the mixtures employed or the relative proportions of coke and iron although heaven knows their name is legion. Some day when I have the time and the inclination, I intend to prepare a lengthy and scholarly monograph on that phase of the subject, illustrated by numerous charts and footnotes. At the present time I shall confine myself to a few pertinent remarks on the manner in which the iron and coke are conveyed from the yard to the charging door of the cupola.

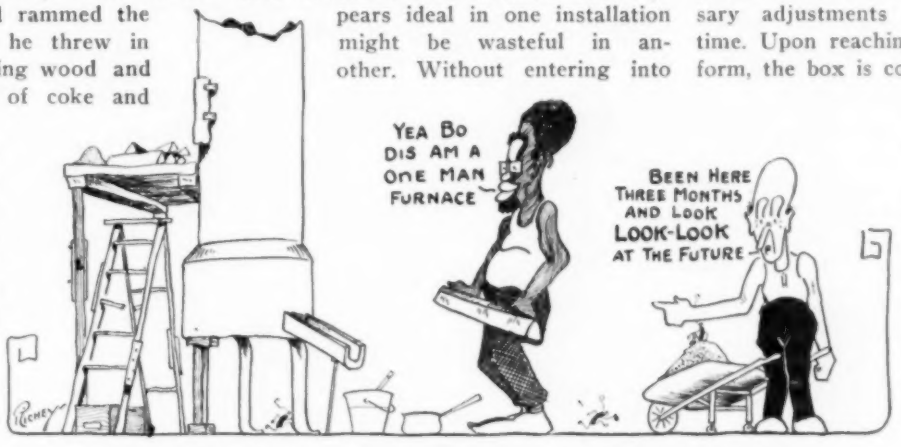
"The most primitive method I ever saw was in a small shop in one of the southern states in which the cupola was tended by an ancient colored individual by the name of Uncle Edward. A little 24-

inch cupola, about 10 feet high was located close to the wall outside one end of the foundry building. The spout projected through the wall so that the furnace could be tapped from the inside. Heats of about 3 tons were taken off every other day.

On the day following a cast, Edward wheeled the cinders away, chipped the cupola, daubed her up and put up the bottom doors. The charging platform was situated about 6 feet from the ground and was reached by a short ladder. He carried about two good riddlefulls of sand up the ladder and dumped them in through the charging door, then he crept down inside with a rammer and rammed the bottom. Afterward he threw in his shavings, kindling wood and about 10 forkfulls of coke and for the remainder of the day busied himself breaking pig iron and scrap. The yard was small and all the material was close to the cupola. He did not bother with an elevator or an inclined railway to get his iron up to the cupola. Not he. He simply stood on the ground and threw the material up on the stage. After he had a sufficient quantity on the stage he lighted the furnace and made up the breast. Then after she had burned through he threw in a few forkfulls of coke to bring the bed up to the proper height and charged the iron and coke in the regular manner. He did not bother with any such trivial detail as weighing the iron, just guessed the amount each time and let it go at that. I worked in that shop for a couple of months and I want to say that I never poured nicer or hotter iron elsewhere.

"The other extreme I witnessed in a large western shop where the iron for the charge was loaded by a crane into a skip car resting on a scale. After a definite amount had been placed in the car, it was pulled up with a cable and automatically dumped into the cupola. Coke was loaded into the car by a grab bucket and dumped into the cupola in a similar manner. In the first instance, one man handled 3 tons of iron in two days and in the second instance two men, one on the yard hoist and the other on the skip handled 100 tons a day.

Between these extremes I have seen probably every combination of methods, but I never yet have seen one that could be adapted to every foundry. Local conditions govern to a considerable extent and a method that appears ideal in one installation might be wasteful in another. Without entering into a controversy on the relative merits of mechanical versus hand charging, it may be said that the labor factor is the main consideration in the problem. This factor in turn is dependent on the number of times the iron is handled between the stock pile and the charging door of the cupola.



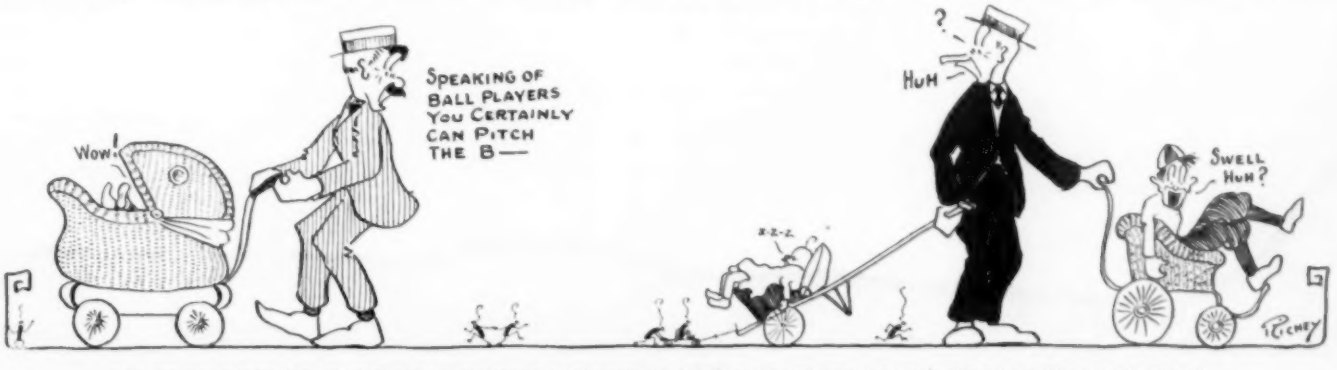
THE CUPOLA PROPOSITION REDUCED TO ITS LOWEST TERMS

"Foundries built in recent years have been designed and equipped to reduce the handling of the charge to a minimum. In many cases small 4-wheel buggies running on a narrow gage track leading from the stock yard to the elevator and passing over a track scale *en route*, are employed. These cars, with a definite amount in each one, are taken up in the elevator and then pushed over close to the charging door of the cupola. The iron is only handled twice, once when it is loaded into the trucks and again when it is lifted out of the trucks and thrown into the cupola.

"In another type of installation, a concrete gangway in the yard takes the place of a track. A number of boxes mounted on skids are provided. The boxes are filled with iron and then are picked up by one of the various types of electric or gasoline operated lift trucks and taken to the elevator. A suitable scale, set flush with the concrete gangway, is located close to the entrance to the elevator shaft. The load is weighed as it passes over the scale and any necessary adjustments are made at that time. Upon reaching the charging platform, the box is conveyed to a suitable point and lowered to the floor. The lift truck returns to the yard and the sequence is repeated. After the entire charge has been stacked on the charging floor, the lift truck is employed to set the loaded boxes in turn close to the charging door of the cupola and return the empty boxes to the yard for the following day.

"Some of the old time foundries have remodeled their charging facilities along these lines, but a considerable number, especially among the smaller shops, still cling to the inclined runway and the wheelbarrow.

"I worked in a shop several years ago which had neither narrow gage tracks or lift trucks, but which nevertheless poured between 40 and 50 tons of iron a day. The charging platform was served by a single air operated elevator and the iron, coke and limestone were conveyed from place to place by wheel barrows. The platform of the elevator could only accommodate two wheel barrows at one time, that is the narrow wheel barrows em-



ALL THE EMINENT PITCHERS ARE NOT CONFINED WITHIN THE RANKS OF ORGANIZED BASE BALL

ployed for wheeling the iron. The large coke barrow monopolized all the space when it went on. It was necessary to employ from six to eight men to get the iron up for the days heat. Delays were unavoidable and it usually was necessary to put on extra men in the afternoon.

"The men loaded the barrows and wheeled them from the stock pile to the entrance of the elevator. Then they had to set them down and wait their turn on the elevator. A couple of minutes lost by 8 or 10 men on an average of 12 times an hour for 6 or 8 hours each day means a couple of days in the aggregate every day.

"On reaching the charging platform the iron was dumped in a miscellaneous pile on the floor. When the time came to charge the cupola the charging crew lifted the iron on to a platform scale, then lifted it off again and threw it into the cupola. The work was hard and heavy and above all it always was in a hurry and it was impossible to keep men at the job. They kept quitting as fast as they were hired. Finally the master mechanic took a hand in the game and solved the problem in an entirely satisfactory manner.

"He cut a gap 10 feet square in the charging floor and installed a scale with a capacity of 50 tons flush with the remainder of the floor. A man was put on duty at night who wheeled up the greater part of the charge. Two men wheeled up the remainder on the following day and since there was no congestion they suffered no delay in waiting for the elevator. The iron was dumped on the scale and when the men started charging all they had to do was to set the indicator on the beam back to any predetermined figure. They threw iron into the furnace until the beam lifted, then set it back again for the second charge and so on until the entire charge was in the cupola. In this manner it was not necessary to make up individual charges taking up a great deal of room. After the beam was set for any required weight, the men selected a sufficient quantity of iron from any part of the pile and threw it into the cupola.

"Well," I said, "that rig probably made the work much easier than it was formerly, but I think if I had any choice in the matter, I should prefer throwing the ball around a few hours every afternoon, to throwing about ten tons of pig iron into a cupola in the same length of time. Besides, the baseball athletes receive about $10,000 a year for doing just about enough work to keep them in good physical condition; while the men who handle the pig iron get just about enough to keep their immortal souls from parting with their bodies."

"That is one of the reasons," said Bill, "why socialism will never prevail. A man's earning capacity depends on his ability to deliver what the people want. You can find 10,000 men capable of throwing pig iron into a cupola for one man capable of cracking a fast one over the fence. Throwing the ball, or its first cousin the bull, is an art confined to specialists, and with all due modesty I want to remark that specialists always are high priced artists."

How and Why in Brass Founding

By Charles Vickers

Antimony Not Used in Trolley Wheel Alloy

Please advise what mixture of metal is considered best for making trolley wheels; also state how it should be melted in an open-flame furnace. Our analysis of satisfactory wheels shows about 85 per cent copper, 5 per cent tin and 10 per cent zinc. However, wheels of that mixture do not seem to be hard enough or tough enough. Do you think it would improve them to add antimony? If so what percentage should be added?

A mixture extensively used for making trolley wheels is: copper, 94.00 per cent; tin, 4.00 per cent; phosphor tin, 2 per cent. The phosphor tin should contain 5 per cent phosphorus. If phosphor copper is preferred to phosphor tin, make the alloy as follows: copper, 93 pounds, 6 ounces; phosphor copper, 10 ounces; tin, 6 pounds. If zinc is preferred to phosphoros, use the following alloy: copper, 92.00 per cent; tin, 6 per cent; zinc, 2 per cent. It is not customary to use more than 2 per cent zinc in high grade trolley wheels. Antimony would harden the wheels but it would also embrittle them, therefore, its use is not advisable. The above formulas will produce good wheels, but more phosphorus can be used if preferred, in fact, trolley wheels have been used in large numbers that were hardened with phosphorus, and contained little tin.

Method of Gating Small Castings

We have had difficulty running yellow brass castings containing aluminum. The castings are of an ornamental nature, being rosettes and shields, the former about 7 inches in diameter, consisting of leaves springing from a central ring. These castings we are unable to run as the mold cuts through along the flutings of the leaves. The runner encircles the casting and the gates from the runner connect to the tips of the leaves and the runner and gate is in the cope as the ornamental part of the casting is coped off. The shield is quite heavy and it runs porous where the gates connect. We have changed the method of gating several times with no better results. We are sending sample castings to guide you in offering suggestions.

The source of the trouble is in the method of gating the castings. Consider the rosette. The surest method of making it on a production basis would be to devise means that would permit the mold to be made with the ornamental face in the nowel, and the gate in the center, on top of the edge of the ring, then with vents drawn from the leaf tips, there would be no question about its running. However, if it is thought this cannot be done, discard the gate now used and substitute for the runner a piece of ½-inch round iron, bent to encircle the pattern, and run gates from this runner to the part that will be the casting, but do not cut them into the ends of the leaves as in the sample. Cut them instead in the form of little trenches into the back of the casting and have one gate running into every little spread of leaf. The small lumps left by the gates can be ground away afterward. Skin-dry the

molds before pouring. In the case of the shield, cope out the back, bend a piece of ½-inch iron for a runner to encircle the pattern and cut the gates in the cope into the top edge of the casting. This casting will run without aluminum, and it will then come clean as the porosity is caused by the aluminum. A good yellow brass molder is required for this class of castings.

White Metal for Patterns

We would like to get the formula for a white metal pattern mixture for duplicating patterns; also a mixture for a malleable brass that would be better than copper, 70 per cent; zinc, 30 per cent.

The following alloy is the most used white metal mixture for making duplicate patterns: Zinc, 50 per cent; tin, 50 per cent. This alloy shrinks little, the rapping to cause the patterns to withdraw from the sand will be sufficient to counteract the shrinkage.

A better casting mixture than 70-30 would be copper 70 per cent, zinc 28 per cent, tin 2 per cent. If the castings have to be machined a little lead is advisable and a mixture consisting of copper 68 per cent, zinc 28 per cent, tin 2 per cent, lead 2 per cent would be satisfactory.

Pouring Thin Castings of Aluminum

We are making light aluminum castings with considerable loss in misrun. The metal thickness is 3/32 to ⅛ inch and the castings are shallow pans about 10 inches in diameter. These we pour two up, and three or four gates to each sprue. We have changed the method of molding, having coped the inside and made them the opposite way, but still though the molds are well vented through the cope the results are not satisfactory. We use a medium fine sand and work it as dry as possible; we use a good grade of No. 12 aluminum, with zinc chloride as a flux. We melt in iron pot furnaces, with kerosene fuel oil and air pressure. If we pour the metal red hot, we save the castings, but because of their appearance when poured hot they are rejected. We have seen castings of this kind that appear to have been poured with cool metal, being smooth and not discolored in the least. We will appreciate any information you may be able to give us.

There are several questions that arise in connection with this problem. One is: are the castings thinner than those of a competitor? The fact that they run when poured hot would indicate the metal thickness is not sufficient. If this question should be decided in favor of the present thickness, then some other method of gating is advisable to secure the desired results.

In connection with the question of gating, we suggest a visit to a foundry making a specialty of stove plate, as the same methods of gating often are applicable to castings made of aluminum. As this casting is a shallow pan, we would favor what is known as a *finger gate* placed on the bottom of the pan, which would be molded with the core in the drag or nowel.

A finger gate is a drop gate, and it is simply a number of little sprues about the thickness of a lead pencil, which are connected to a basin into which the metal is poured from the ladle. To properly describe this gate, illustrations are necessary, but it can be seen in use in any stove plate shop.

Proper Alloys for Making Aluminum Pistons

We would like to get a formula suitable for aluminum automobile pistons.

A large number of different aluminum alloys are in service as pistons of automotive engines. Perhaps the alloy most generally used consists of aluminum 88 per cent and copper 12 per cent. Such alloys are comparatively weak at ordinary temperatures and strong at the working temperature of a piston.

With iron at 1 per cent and copper at 14 per cent, the strength of the alloy at high temperatures is greater than that of the straight copper 12 per cent, aluminum 88 per cent. We suggest the latter alloy be used. It is made by melting together pure commercial ingot aluminum and a hardener consisting of 50 per cent copper, 50 per cent aluminum in the proportions of 24 per cent hardener and 76 per cent aluminum.

Deoxidizing Copper

We have experienced difficulty in using boron copper for making copper castings having a conductivity of 80 per cent or upwards. Our method of melting is with coke-fired, pit-type crucible furnaces, and we have been using about 3 per cent of boron copper shot or granules; but it frequently happens that the runner heads have risen instead of sinking, with resulting porosity. The majority of the castings weigh about 7 pounds and have a core through the center. We have tried thoroughly venting the molds, also skin drying, and have obtained some better results, but there is room for much more improvement.

We fail to see how the so-called boron copper can be of any value in connection with deoxidizing copper to produce sound castings of high electrical conductivity, for the simple reason that boron is not taken up by copper. It follows, therefore, that there can be no boron in the *boron copper*, so, if it contains no other element such as phosphorus, it is simply shotted copper. There are several methods of making high conductivity copper castings. By one method a very small addition of silicon is employed, and the copper is melted in a closed electric or similar furnace so that it can be poled until a tough pitch condition is reached. Then a small addition represented by about 2 ounces of 10 per cent silicon copper, per hundred pounds of copper, is made. In place of the silicon copper, another method is to use a small addition of phosphor copper, in about the same proportion as the silicon copper. There are also alloys especially for deoxidizing copper, which contain silicon and magnesium and other elements, dissolved in a base of copper. With careful melting of the copper it is possible to get sound castings if 0.25 per cent of a 10 per cent silicon copper is used. This will give castings of creditable conductivity.

Nonshrinkable Brass Formula Kept Secret

We are using two formulas for white-metal patterns. The one is made of tin, 7 pounds, and antimony, 1 pound. The other is composed of lead, 5 pounds; tin, 3 pounds; antimony, 1 pound. Both alloys are nonshrinkable, but the first can be employed only for shop use as it is expensive, and the second is rather soft. What we want is a nonshrinkable brass suitable for pattern use.

We regret our inability to furnish the formula for a brass having no shrinkages, as there is little doubt such a formula would be very valuable for many purposes. Those that have mastered this secret keep it so closely guarded that not the slightest inkling of its composition has leaked out. We believe it to be a fact that a large percentage of nonferrous metallurgists would regard such an alloy as being an impossibility. However, we have an open mind on this subject, and are ready to welcome any suggestions in regard to making such an alloy. A white metal frequently used for pattern work consists of 50 per cent zinc and 50 per cent tin. This alloy possesses only a slight shrinkage.

How Small Brass Castings Are Made

In Addition to Describing the Methods Involved in Planning Production To Meet Delivery Requirements the Routine Work Incidental to Molding, Pouring, Melting and Cleaning the Castings Is Described

BY RAYMOND H. SULLIVAN

THE object of this paper is to outline some features of the problem involved in producing a large number of small duplicate nonferrous castings and to describe briefly the methods adopted by the Yale & Towne Mfg. Stamford Conn., for their solution. The principles involved in the production of the casting selected for illustration are typical of those employed for several thousand somewhat similar castings but varying in shape, size and composition. Some 30 base formulas are used in the composition of the various castings ranging from bronzes involving high tensile strength and a large percentage of ductility to clear, soft, high finish brasses and bronzes where colors are the prime requisite rather than strength.

While the processes described are employed in quantity production, castings are not produced under continuous operating conditions, day in and day out; consequently the greatest application of semiautomatic or full automatic equipment, such as traveling conveyors or rotating tables, etc., for handling molds, cannot be utilized. It is fully realized that where small identical castings are produced day in and day out, year in and year out, a much more efficient method than described in this article can be

From a paper presented at the Columbus convention of the American Foundrymen's association. The author is connected with the Yale & Towne Mfg. Co., Stamford, Conn.

This description, therefore, is intended to show how production is obtained in a large foundry, with a large variation in output of small brass and bronze castings in quantities varying from two to 50,000 pieces per order and which run in production time on one set-up of molding machines from three days to three months.

The fact that nonferrous castings of 40,000 different parts are ordered from the foundry during the normal year, of which approximately 10 per cent are ordered in large quantities, necessitates careful planning and close adherence to the plans, in order to insure delivery of the castings when required.

The basis for this planning is a schedule issued each half year. This schedule consists of quantities of units, the quantities being based on the sales of the preceding six months and the judgment of the sales and stock organizations in conference. From this schedule, which is in terms of product units, a plan is laid out to cover the manufacture of each of the parts entering into these units, in each of the various departments in which work is performed on them. This plan is received in the brass foundry by a dispatch clerk, who is the representative of the production bureau, a part of the executive organization which controls and plans production throughout the plant. The dispatch clerk immediately enters requisitions for the manufacture of cores, based on the actual working time to produce them and to insure their delivery a day in advance of the date upon which it will be necessary to start the actual molding in order to meet the plan.

The molding date is calculated from the actual man hours required to produce the quantity of castings on any order. The dispatch also orders patterns to be delivered from the pattern vault a day in advance of the actual molding date. These patterns are delivered to the pattern rack in the foreman's office and represent the work which he must have in the sand on the succeeding day. By using a tickler system, the dispatcher can be certain that the cores and patterns are actually delivered at the required time.

The foundry foreman, by using the information of the dispatch clerk and in close co-operation with him, has an opportunity to know a considerable time in advance whether the required production is increasing or decreasing and is enabled to plan accordingly.

As an additional control against the possibility of failure to produce, a curve showing the total delivery of castings for each class of product, as against the required delivery is kept on a card in the office.

The pattern shown in Fig. 3 consists of a gate of 16 pieces which is permanently fastened to a cast iron

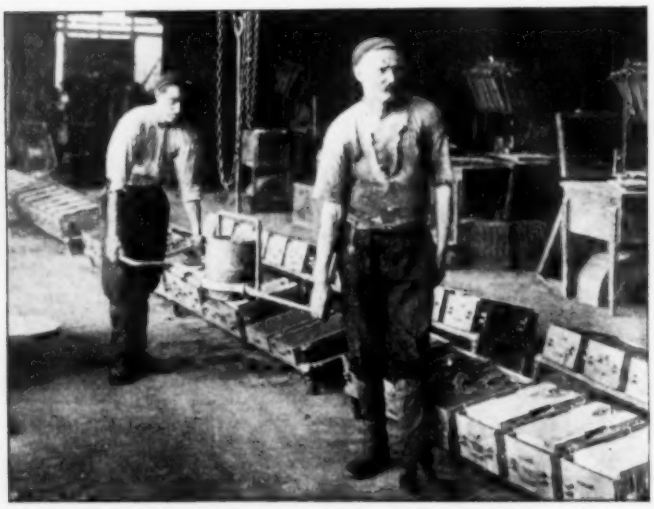


FIG. 1—THE CRUCIBLES ARE COVERED BY CHAIN HOISTS SUSPENDED FROM I-BEAMS OVER EACH FLOOR. FIG. 2—THE MOLDS ARE ARRANGED FOR POURING ON INCLINED STANDS—EACH MOLDER POURS AND SKIMS HIS OWN METAL

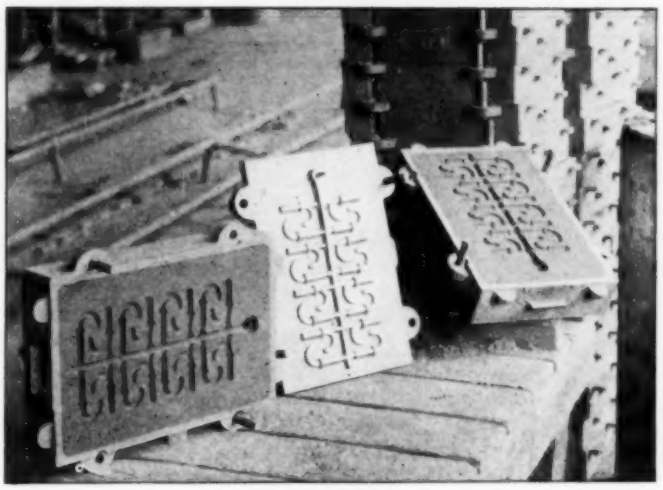


FIG. 3—GATES PATTERNS AND TWO HALVES OF FINISHED MOLD

FIG. 4—TO INSURE ABSOLUTE ACCURACY THE FLASKS ARE PROVIDED WITH FOUR PINS, TWO IN THE COPE AND TWO IN THE DRAG

plate containing one half of the gate and castings which make a complete mold when the cope and nowel halves of the mold are placed together.

The molding is done on an air squeezer machine, Fig. 4. The cope and nowel are made from the same pattern and a sprue is provided for in the cope board. Care must be exercised by the patternmaker in setting the pattern exactly in the center of the plate, otherwise a shift will occur, spoiling the casting. Fig. 7 shows the general layout of the molding floor, including a number of molding machines. A number of gates of finished castings also are shown.

The molder is provided with a helper, Fig. 6, whose duty it is to graphite the flask pins and carefully clean the flanges of the metal flasks, thereby preventing a possibility of a thicker casting than desired. He likewise sets the finished mold on the pouring rack, puts on the weights and, after a rack of molds is poured, shifts the weights and breaks off the sprue heads of the hot gates. The result of these various operations can be noted in Fig. 7.

Every pair of molders has one extra helper who dumps the molds, removes the castings and puts back the empty flasks at the molders' benches. This being done, he wets and cuts the sand.

Upon completion of the day's work, the three helpers clean up the two floors and return the backstock to the metal cage, where a responsible man is stationed to see that it is not mixed with other metals of different composition.

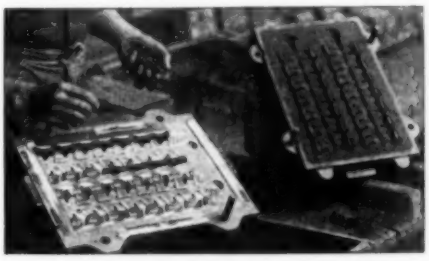


FIG. 5—THE CORES FIRST ARE MADE IN A PLASTER MATCH—THE DRAG PART OF THE MOLD IS SET ON IN AN INVERTED POSITION AFTER WHICH BOTH ARE ROLLED OVER

The hot metal for the castings is carried to the molders by two-bar holders in a No. 25 crucible, which has been previously preheated. The molder skims and pours his own metal, as shown in Fig. 2, and in this way becomes so well acquainted with the heat that he can readily decide when his metal is at the proper pouring temperature. Molders are chosen from the helpers by careful observation of the foremen and, with systematic training by regular instructors, are developed into competent workmen.

After the castings are dumped from the molds and sufficiently cool for handling, they are taken by truck, as indicated in Fig. 7, to the cutting off room, where they are chopped from the gates as shown in Fig. 7, each man's work being kept separate. The gates are likewise kept separate in order to avoid the mixing of the different metal mixtures. An interest-

FIG. 6—EACH MOLDER HAS A HELPER WHO KEEPS HIM SUPPLIED WITH EMPTY FLASKS AND WHO TAKES AWAY THE FINISHED MOLDS AS FAST AS THEY ARE MADE—FIG. 7—GENERAL VIEW OF THE MOLDING FLOORS—ONE OF THE PIPES CONNECTED WITH THE VENTILATING SYSTEM IS SHOWN AT V

FIG. 8—A PNEUMATIC HAMMER IS EMPLOYED FOR JARRING THE CORES OUT OF THE SMALL CASTINGS. FIG. 9—MOST OF THE CASTINGS ARE SANDBLASTED WHILE STILL ON THE GATES

ing innovation recently installed is also shown in Fig. 7. This consists of an air hammer used to vibrate gates of castings containing cores. This system quickly and efficiently removes the cores.

The castings then are removed to the grinders who grind off the remainder of the gate left on by the choppers. From the grinders the castings are removed to the sand blast machines, Fig. 9, where they are sand blasted for approximately 10 minutes, after which they are taken to the inspectors who carefully separate the good work and make their returns on a ticket for the benefit of the time-keeping department. Molders are paid only for good castings. These operations having been completed, the castings are tumbled in wet tumbling barrels, Fig. 10, for about seven or eight minutes when they are weighed and shipped according to designated routing on a special "move" ticket.

An alternate procedure frequently is followed in the cutting-off room. Instead of first chopping the castings from the gate they are sand blasted on the gate, and then chopped and ground. By this method, the backstock is rid of the undesirable sand which clings to the gate and gets into the heat in which this backstock is used. While preferable to the choppers and grinders from a standpoint of cleanliness, this method is slower and therefore, is not used except occasionally when operating conditions warrant it.

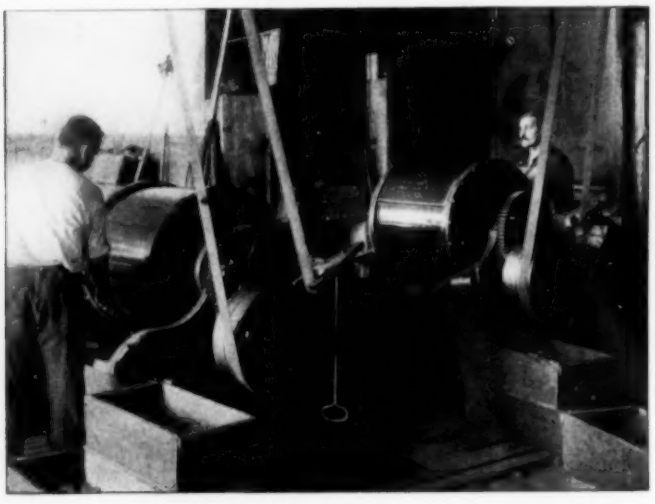
Core Setting Device

A molder on this pattern averages approximately 20 molds per hour, giving a production of about 180 molds per day, 16 pieces per mold, or in all about 2880 castings. Deductions are made in the molder's pay should losses occur due to faulty work on his part. This has a tendency to keep the molder on the lookout for pouring his metal properly and prevents his putting up molds in a careless manner.

A very exact and convenient means of setting cores for a mold requiring numerous cores is shown in Fig. 5. A plaster paris mold is made which corresponds to the mold in which the cores are to be set. The core setter sets the cores on the plaster paris mold and the molder, on completing the nowel half sets it on a plastermold. Upon reversing the nowel prior to placing the core half we find the cores neatly set without disturbing the sand in the nowel. This method has proved to be very advantageous and is now used to a great extent.

Fig. 11 shows a general view of the tub molding floor with the machine molding floor in the background.

Several of the metal mixtures in use contain some turnings or scrap. Brass and bronze scrap from all over the works is sent to the salvage division, where that part of it considered satisfactory for use without refining is selected and stored in the melting room. The skeleton scrap and defective castings and all of that scrap which is likely to contain iron parts is screened and a hand magnet run through to remove iron or steel parts. The turnings are run through riddlings and magnetic machines and the rod turnings burned to remove the oil. A part of this scrap in turnings is



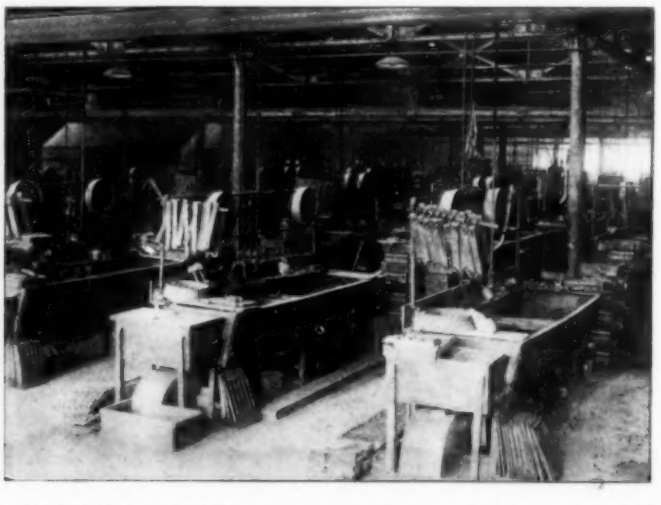


FIG. 10—THE CASTINGS ARE GIVEN A FINAL FINISH IN WET TUMBLING BARRELS. FIG. 11—TUB MOLDING FLOORS WHERE THE FLASKS ARE RAMMED BY HAND

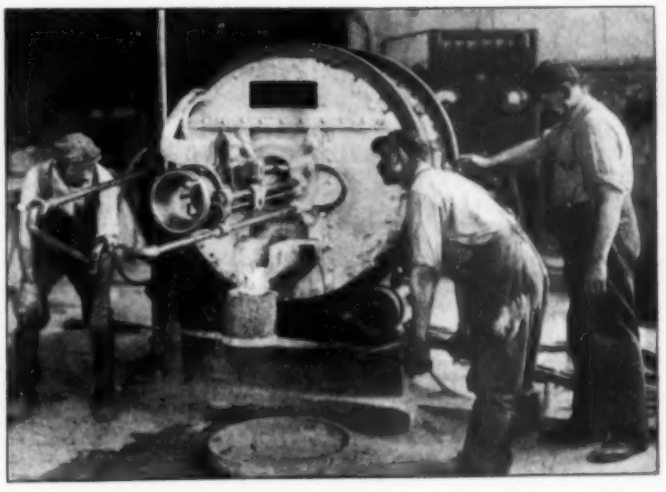


FIG. 12—FOUR HEATS A DAY ARE MELTED IN EACH OF THESE OIL MELTING FURNACES. FIG. 13—ONE OF A NUMBER OF ELECTRIC FURNACES RECENTLY INSTALLED

then analyzed and recorded to permit of a correct mixture when the new metal is added.

All of the new metal is stored in a metal cage and upon being issued to the melter, the weight of the charge is carefully checked three times.

The metal for casting the shackles is regularly melted in oil furnaces in crucibles. Experiments with electric melting are now in progress and seem to meet with success.

In oil melting, a melter supervises the melting for three furnaces with a helper for each two furnaces. An hour in advance of the time for the molders to commence work in the morning, the melter with his helper weighs out one day's supply of scrap and turnings. This scrap is fed to the furnace as fast as it melts down and when just hot enough to pour, is cast into ingots. Fig. 12 shows pouring off from one of a large battery of oil furnaces.

Four Heats a Day's Work

Four heats per furnace of 170 pounds each is considered a day's work. The ingots are then reweighed by the melter and the new metal for each charge drawn from the metal cage. The charge is melted down from ingots and new metal in proper ratio and covered with charcoal before it reaches a temperature at which it is easily oxidized and remains covered until poured. It is then carried to the molds in No. 25 crucibles, by means of an overhead trolley system, as shown in Fig. 1, the crucibles having been preheated to a temperature depending upon the size of castings to be poured. Four heats of 170 pounds per day is the task for this work, the molders working from 6 a. m. until about 4:30 p. m. At the end of the day's work the melter gives the cage checker a card showing the amount of metal melted and this is checked against the amount of alloy issued to him. All ingots which have been poured by a melter are weighed and stored in the metal cage each day.

In the experiments now being undertaken with electric melting the handling of the metal up to the point of charging the scrap and turnings to the furnace is exactly the same as in the oil furnace. Approximately 200 pounds of turnings and scrap mixture are charged into the furnace and heated for about 20 minutes at from 40 to 50 kilowatt-hours. The furnace is oscillated to mix this melt at intervals of approximately two minutes until the input reaches 80 kilowatt-hours, when the mixing process is operated continuously until approximately 100 kilowatt-hours have been used. The new metal is then charged and the heating continued until about 110 kilowatt-hours have been consumed. No charcoal is used, there being but small openings through which the metal could be exposed to the air. The molten metal is then carried to the molds in exactly the same manner, as that used with the oil furnace. Six heats of approximately 600 pounds can be melted per day.

With this method the scrap is not molded into ingots but the new metal is added directly to the molten scrap and turnings. At the end of the day's run, the melter gives the cage checker a card showing the total amount of metal melted and this is checked against the amount issued against him. The elimination of making scrap into ingots results in a very large saving.

The experiments thus far indicate that electric melting is considerably more economical than oil melting. In melting direct from the oil furnace into the molds the experiments indicate that electric melting saves about 38 per cent. When double melting is employed in using turnings, melting first into ingots, then ingots remelted with new metal, a gain of about 70 per cent is indicated by the experiments with electric melting.

Too much emphasis cannot be laid upon the importance of records, not only of composition and analysis, but records of production, output, backstock, losses, reclamation, output per molder, etc. Records to the production foreman or superintendent are a large factor in guidance in obtaining efficiency of operation. Efficiency of operation is the basis of low costs in production.

The conclusions to be drawn from the experiments of electric melting described, indicate, that the trend of nonferrous foundry melting is rapidly leading to the adoption of electric melting.

No attempt in this paper is made to describe the various types of electric furnaces, as the writer believes that each particular foundry must make a thorough analysis of the various types of furnaces and systems of melting now offered by the manufacturers and by a process of elimination, determine upon the particular type or system best adapted to its product.

Erects New Plant

The Amsler Morton Co., Sharpsburg, Pa., recently took over the Etna Foundry Co. and erected a new plant which, with the other establishment will greatly increase its capacity. The new plant is in Parkview, Pa., and will be equipped to manufacture malleable iron as well as gray iron castings.

A new 10-ton furnace recently installed by the Electric Furnace Construction Co., Philadelphia, has been started at the works of the Sociedad Espanola de Construccion Naval, Spain. This is said to be the first large electric furnace to be operated in that country.

THE FOUNDRY

Registered U. S. Patent Office

A semimonthly journal devoted to all branches of the foundry trade

Published by
THE PENTON PUBLISHING CO., CLEVELAND

BRANCH OFFICES

BOSTON.....426 Old South Bldg.
CHICAGO.....1147 Peoples Gas Bldg.
CINCINNATI.....501-505 Commercial Tribune Bldg.
NEW YORK.....2203-2206 St. Paul Bldg.
PITTSBURGH.....2148-49 Oliver Bldg.
WASHINGTON, D. C.....40 Metzerott Bldg.

FOREIGN OFFICES

BIRMINGHAM, ENG.....Prince's Chambers
LONDON, ENG.....2-4 Caxton House, Westminster
Cable Address, IROTRAPEN, London

SUBSCRIPTION

United States and Mexico.....$3.00 a year
Canada.....$4.00 a year
Great Britain and other Foreign Countries.....$5.00 a year
Single Copies.....25 cents
Copies published three months or more previous to date of current issue, 50 cents each

ADVERTISING

All communications relating to advertising copy, discontinuances, etc., must be received on the 1st and 15th of the month preceding date of publication.

Member, the Audit Bureau of Circulation and Associated Business Papers Incorporated

Entered at the Post Office at Cleveland as Second Class Matter

Copyright 1921 by the Penton Publishing Co.

Contents

	Page
From the Foundry to the Speedway	459
Zinc Output Increases	462
Reviews British Pyrometry Practice	463
Protecting Cores from Phosphor Bronze	467
Small Cupola is Feasible	467
Book Review	467
Electric Melting Nonferrous Alloys	468
British Associations Honor Publisher	474
Checking Troubles in Steel Castings	475
Correcting Flaws in Metals and Mixes	484
Electric Furnace Melting Recommended	484
Annealing Will Soften Gray Iron Castings	484
Production of Piano Plates	484
Keeping Slag from Castings	484
Cupola Melting Losses	484
Two Formulas for Making Sand Matches	484
Tunnel Castings Requirements are Large	485
Bill Compares Ball Players with Cupola Men	486
How and Why in Brass Founding	488
Antimony Not Used in Trolley Wheel Alloy	488
Method of Gating Small Castings	488
White Metal for Patterns	489
Pouring Thin Castings of Aluminum	489
Proper Alloys for Making Aluminum Pistons	489
Deoxidizing Copper	489
Nonshrinkable Brass Alloy Kept Secret	489
How Small Brass Castings are Made	490
Tradition and Custom Die Hard	494
Trade Outlook in the Foundry Industry	495
Comings and Goings of Foundrymen	496
Malleable Accountants Hold Session	496
Select New Officers for Detroit Association	496
Offers Prize for Hardness Testing Machine	496
Foundrymen's Association to Meet Next Spring	497
Death of W. A. Jones	497
A Turbine Driven Grinder	497
Cutting Cast Iron Plates with Oxyacetylene	497
Table Equipped for Use with Swing Saw	498
Metal Cutting Band Saw Requires No Care	498
Graphite Imports Lower	498
Tool Company Organized	498
Obituary	498
Equipment Market Remains Inactive	499
What the Foundries Are Doing	499
New Trade Publications	500

Tradition and Custom Die Hard

CONSIDERING the question in its broader aspect it may be said that men constitutionally are opposed to changes and innovations. They do not take kindly to proposed changes in established practice. Because a certain thing always has been done in a certain way seems to constitute a sufficient reason for continuing the practice indefinitely. Anyone who departs from the beaten path is regarded either with open hostility or with a measure of kindly toleration depending on whether his actions tend to interfere with the pet theories of other people.

The foundry business, especially in recent years, has had its share of pioneers who blazed new trails into hitherto unexplored territory. Also it has had its share of doubting Thomases who not only decried the proposals advanced by these pioneers but also refused to accept the conclusions and persisted in carrying on their business along obsolete lines.

From its very nature the molder's trade always has been shrouded more or less in mystery. So many variables enter into the preparation of a mold that at times it is impossible to say which of them or which combination may be responsible for a defective casting. In nearly all other branches of the mechanical arts, the craftsman can watch the progress of his work, supply any deficiences, test it at various stages and assure himself in various ways that when the job is finished it will be satisfactory.

The molder has none of these guide posts to help him on the way, all he can do is to follow established precedent. The only test he can apply is the final test of pouring the metal into the completed mold. If the mold stands up to the test well and good; but if not, he cannot suspend operations while he looks for the factor responsible for the trouble. The symptoms of the causes of many defective castings are familiar to all foundrymen and they are in position to apply preventive measures intelligently. Other causes are more obscure and considerable experimenting is necessary before a remedy can be prepared and applied.

In the course of his experiments the foundryman may institute many changes and finally when he succeeds in turning out a perfect casting, he may be at loss to determine which one of these changes has been responsible for his success, consequently he retains them all, having little incentive to experiment further.

Covering the risers is one of the traditions that has obtained through many generations of molders and one that has not yet died out. Of course, it is a harmless custom, one of the extra precautions taken by some dead and forgotten molder under the mistaken impression that the air in a mold can be compressed and thus help to keep the walls of the mold intact. Old time foundrymen can recall when they were assured with the greatest solemnity that the heated and compressed air in the mold prevented the surface of the cope from *drawing down*.

The advent of the molding machine with its intensive production has done a great deal to eliminate this and many other customs of a like nature from the foundry of today. In line with the prevailing spirit of the times, the rising generation of foundrymen is developing a *show me* attitude. While it is improbable that a method ever will be devised whereby molds will be made automatically and without any attendant risk it seems reasonably certain that in future a practice will require a stronger argument for its retention than that contained in hoary and ancient tradition.

Trade Outlook in the Foundry Industry

ANNOUNCEMENT of pending reductions in railway wages for skilled labor is the most encouraging sign of the early weeks of June. This seems to presage a reduction in freight rates, and this in turn will be taken generally as the most tangible sign of returning industrial activity. Railway executives are expressing themselves as dissatisfied with the amount of the reduction and some seem to be striving to hold the present rates in effect at least until the end of the year.

Lower Rates Needed

That lower freight charges would stimulate business is undisputed, particularly as refers to the transportation of the bulky commodities. The main benefit would be in bringing down production costs in the basic industries, and assisting to give a better price balance throughout the business world. Contrary to common belief, a reduction could be effected within a short time. An order from the interstate commerce commission could bring about a percentage reduction within a few days, and such action is expected by many, before the middle of July. The railroads themselves cannot profit as long as the prohibitive rates are continued. This was shown conclusively during the past few months. Even at present, the buying of urgently needed repairs forms the only activity in the railway equipment market. Orders for freight cars during May totaled less than 300 cars, and deliveries were made on 5623 cars, during April according to the monthly statement of the Railway Car Manufacturers' association. This total delivered has been dropping steadily, showing 6453 in March as compared with 7827 in January.

Malleable Shops

Malleable foundries specializing in railway work are practically all at a standstill. The amount of repair business is so meager as to furnish only occasional orders. Those which handle other classes of castings have been more fortunate, but the average operation in malleable plants throughout the country still is at a low level, probably below 23 per cent. The automotive lines promise less for June than for May. While the builders of low priced cars continue on fair schedules, many of the medium priced automobile plants are closing down. Tractor and truck manufacturers did not experience the May revival in business, but continue at probably less than 50 per cent operation. Machine tool lines are exceedingly quiet and but little casting business is in sight from this quarter. Stove and furnace manufacturers continue to manufacture with restricted output, although sales have dropped away to the point where it is difficult to estimate future demand. Some, notably in the vicinity of St. Louis and through western Illinois and parts of Indiana, have adopted a general policy of manufacturing sufficient heating units to take care of about 50 per cent of normal demand, anticipating a revival of interest in the fall. Some foundries making stoves or furnaces for the larger mail order houses and for building supply houses are operating nearly at capacity on stock, but the sale of these units throughout the country is slow.

Public Not Buying

An official of a western stove company states that the public still will not buy, particularly throughout the agricultural sections. An offer of a manufacturer's guarantee against price declines is met with a steadfast refusal to purchase, the consumers regarding such a promise with suspicion. They regard a price guarantee as an effort on the part of the manufacturer to continue high prices and again, to get into production without making reductions in wages nor writing off losses on high priced raw materials. The same attitude is evident also in other lines, extending even to the purchase of pipe and casting sundries for public improvements. Foundries making plumbing goods and domestic hardware have not been so severely affected during the past months, and the revival of building promises better conditions throughout the remainder of the summer. One of the largest manufacturers of sanitary ware is reported to be operating two of its four plants at slightly better than 50 per cent of normal. According to statistics gathered by the *Iron Trade Review*, the production of pig iron in May showed a slight increase over April. The May total is 1,215,187 tons while April showed 1,190,751 tons, an increase for the past month of 24,436 tons in total output. However, the daily average production tells a different story. The daily output of pig iron for April was 39,691 tons and for May it was 39,199 tons. The latter is the lowest figure recorded since June, 1908. The total of merchant iron manufactured in April was 238,539 tons and in May it was 239,179 tons, giving a gain of 640 tons. Here again, the gain was evident only in the total. The daily output of merchant pig iron for April was 7,951 tons and for May it was only 7,715 tons, giving a loss of 236 tons or about 3 per cent as compared with the previous month. At the close of April 96 furnaces were in blast, making all classes of pig iron. The last day of May found only 89 in operation.

Nonferrous shops share the fortunes of other foundries and are operating far below normal. Prices for nonferrous metals based on New York quotations in the *Daily Metal Trade* for May 7 follow: Casting copper, 12.37½c to 12.50c; Lake copper, 13.50c; lead, 4.75c; antimony, 5.12½c; Straits tin, 29½c; aluminum, No. 12 alloy, producers' price, 27.30c and open market, 18.00c. Zinc is 4.50c, E. St. Louis, Ill.

Prices of Raw Material for Foundry Use

CORRECTED TO JUNE 7

Iron		Scrap	
No. 2 Foundry, Valley	$22.50 to 23.00	Heavy melting steel, Valley	$12.00 to 12.50
No. 2 Southern, Birmingham	22.00 to 23.00	Heavy melting steel, Pitts.	13.00 to 13.50
No. 2 Foundry, Chicago	22.50 to 24.00	Heavy melting steel, Chicago	11.50 to 12.00
No. 2 Foundry, Philadelphia	24.85 to 25.50	Stove plate, Chicago	14.50 to 15.00
No. 2 Foundry, Buffalo	23.00 to 25.00	No. 1 cast, Chicago	15.60 to 16.00
Basic, Valley	21.50 to 22.00	No. 1 cast, Philadelphia	18.00 to 19.00
Basic, Buffalo	25.00 to 26.00	No. 1 cast, Birmingham	13.00 to 13.50
Malleable, Chicago	23.00	No. 1 cast, Buffalo	18.00 to 18.25
Malleable, Buffalo	24.00 to 25.00	Car wheels, iron, Pittsburgh	14.00 to 15.00
Coke		Car wheels, iron, Chicago	14.50 to 15.00
Connellsville foundry coke	$ 4.00 to 5.00	Railroad malleable, Chicago	14.00 to 14.50
Wise county foundry coke	6.50 to 8.00	Agricultural mal., Chicago	14.00 to 14.50
		Railroad malleable, Buffalo	11.50 to 12.50

Comings and Goings of Foundrymen

BRADLEY Stoughton's resignation as secretary of the American Institute of Mining and Metallurgical Engineers, which office he held since 1913, has been accepted by the institute's board of directors. He will termine his services after a successor is elected and has become familiar with the work. In accepting Dr. Stoughton's resignation, the directors of the institute formally expressed their recognition of the benefits which his work has brought to the institute. The statement also records the growth of the institute under Dr. Stoughton from a membership of 3500 in 1912 to more than 9000 at this time. It points out that the only technical committee in 1912 was the iron and steel committee, whereas 18 committees now cover the various departments of the institute's field. The number of local sections in that period has been increased from four to 26. Dr. Stoughton previously had sought to retire as secretary of the institute, but had been persuaded by the directors to defer such action.

F. B. McConnell, treasurer, the Columbiana Foundry Co., McKeesport, Pa., has recovered from an appendicitis operation.

William H. Woodin, president of the American Car & Foundry Co., has been elected a director of the American Beet Sugar Co.

Henry C. Knox, formerly treasurer of the American Brake Shoe & Foundry Co., has been admitted as a partner in the firm of Brumley, Chamberlin & Co., New York.

F. C. Carts, general inspector, the Columbiana Foundry Co. has been moved from the Columbiana Ohio plant of that interest to the McKeesport Pennsylvania plant.

Robert E Belt secretary, the American Malleable Castings association, Cleveland, addressed a recent meeting of the National Industrial Cost conference at East Aurora, N. Y., on the subject "Uniform Cost Systems and Their Weaknesses."

E. J. Woodison, president, E. J. Woodison Co., Detroit, manufacturer of foundry supplies and equipment, has been elected president of the Foundry Supply Manufacturers' association, to succeed J. S. McCormick, J. S. McCormick Co., Pittsburgh.

John H. Dwight, formerly manager of the Belle City Malleable Iron Co., Racine Wis., who later joined the Saginaw Products Co. division of the General Motors Corp., Saginaw, Mich., as assistant general manager, has been promoted to general manager, succeeding A. L. Hannum, who is transferred to the Oldsmobile works at Pontiac, Mich.

W. H. McCurdy, Hercules Gas Engine Co., Evansville, Ind., with F. C. Gardner, E. C. Atkins & Co., Indianapolis, and Elwood Haynes, Haynes Automobile Co. and Haynes Stellite Co., Kokomo, Ind., have been selected as three of the six industrial leaders of the state to participate in a national organization to aid in developing college and university education.

Fred K. Heiner recently has been made foundry superintendent for the Ferrum Casting Co., Inc., Middletown, N. Y. This is a new foundry constructed for the manufacture of machinery and jobbing gray iron castings. Mr. Heiner who was graduated by McLain's System, Inc., Milwaukee, formerly was employed by the Bethlehem Steel Corp., Baltimore, and previous to that time with the American Locomotive Works, the General Electric Co., Schenectady, N. Y., and Pusey & Jones Co., Philadelphia.

Dexter S. Kimball, dean of the College of Engineering, Cornell University, Ithaca, N. Y., has been nominated president of the American Society of Mechanical Engineers. Dean Kimball who was elected to the society in 1900 was chosen manager in 1919. He is vice president of the Federated American Engineering Societies. Three vice presidents also were nominated. These are Col. E. A. Deeds, Dayton, O.; Robert Sibley, San Francisco; and L. E. Strothman, Milwaukee. William H. Wiley, New York, again has been nominated as treasurer. He has held this office each year since 1884. The nominations will be voted on by letter ballot and the election announced at the annual meeting of the society in December.

Malleable Accountants Hold Session

A meeting of accountants of the American Malleable Castings association was held at East Aurora, N. Y., June 13 and 14. The program included "Preparation of Cost Data for the Executive", by Thomas J. O'Brien, Fort Pitt Malleable Iron Co., Pittsburgh; "The Application of a Normal Burden or Overhead Distribution to Costs During Periods of Lessened Production", by C. E. Swank, Dayton Malleable Iron Co., Dayton, O.; "Methods of Securing Necessary Cost Data from the Operating departments", by Ray H. Eisenlord, Erie Malleable Iron Co., Erie, Pa.; "Distribution of Expense Items", by Arthur J. Whitman, Eastern Malleable Iron Co., Naugatuck, Conn.; and "Coordinating Cost Work with the General Ledger," by N. J. Schmidt, Rockford Malleable Iron Works, Rockford, Ill.

Robert E. Belt, is secretary of the association with offices at 1900 Euclid building, Cleveland.

Select New Officers for Detroit Association

The Detroit Foundrymen's association held its annual banquet at the Fellowcraft club, Detroit, May 19. This occasion marked the annual election of officers and the following were chosen for the ensuing year: Fred Erb, Packard Motor Car Co., president; E. S. Van Dalson, Dodge Brothers, vice president; H. J. Brady, Aluminum Manufactures, Inc., secretary and J. R. Stewart, General Aluminum & Brass Mfg. Co., treasurer.

Mr. Erb, Mr. Brady and Mr. Stewart all were re-elected. J. C. Woodison, The E. J. Woodison Co., and J. D. Stoddard, The Detroit Testing Laboratory, were newly elected members of the executive board. The Detroit association now numbers almost 200 members. During the past season nine meetings were held and an average attendance of 75 was reported.

Offers Prize for Hardness Testing Machine

Sir Robert Hadfield, to whom the John Fritz medal for his invention of manganese steel will be presented at the opening meeting of the British Institution of Civil Engineers on June 29, has offered a prize for the best design of an apparatus to determine the hardness of material accurately. This apparatus must be suitable for application in metallurgical work for cases in which present methods partially fail, according to an nouncement by the American Society of Mechanical Engineers.

The award or awards, which are offered through the Institution of Mechanical Engineers of Great Britain, will be made by the council of the institution. The present funds amount to £154. A portion of the fund may be awarded for communications which advance the knowledge of methods of testing hardness. All communications submitted for the prize should be accompanied by scale drawings or by models or examples of the apparatus, and should reach the secretary of the institution by Dec. 1, 1921. If the communication is likely to be of commercial value it is suggested that provisional protection should be obtained before submitting the idea.

Foundrymen's Association To Meet Next Spring

From the date of organization to 1911 conventions of the American Foundrymen's association were held in May or June of each year. In 1912 it was found necessary to postpone the convention scheduled for June at Buffalo until late in September, due to delay in completing the building in which the exhibits were to be placed. Since that time the annual meetings have been held in the fall.

At the annual meeting of the board of directors of the association, in Rochester, N. Y., December 7, 1920, invitations for the next conventions were referred to the committee on convention and exhibits. When this committee met in Cleveland on March 30, to consider the place of the next meeting, it was found that in none of the eight cities considered was it possible to find, during September or October, adequate hotel accommodations and exhibition facilities properly to care for such meetings as were held in 1919 and 1920. Confronted by this situation and general industrial conditions, the committee recommended to the board of directors that the convention be held in New York City, in October or November of this year, without exhibits.

This recommendation was referred by letter to the members of the board and expressions of opinion requested. On May 28 the executive committee of the board met, and after due consideration of the recommendations of the committee, and the expressions of opinion by the members of the board, it was unanimously resolved that the next convention and exhibit of the American Foundrymen's Association be held in April or May, 1922, at a place to be selected by the convention and exhibits committee. The place and date will be announced later.

Death of W. A. Jones

W. A. Jones, president of the W. A. Jones Foundry & Machine Co., Chicago, died May 30 at his home in La Porte, Ind., aged 71 years. He suffered an apoplectic stroke about a year ago and had been in ill health since that time. Mr. Jones was widely known in the foundry industry. He was in business at Marseilles, Ill., for several years, after which he removed to Chicago where he was connected with the Link-Belt Co. In 1890, he founded the W. A. Jones Foundry & Machine Co. and was active in that company until he retired from active business several years ago. He specialized in pulleys and transmission machinery and for years was known widely as "Pulley" Jones. He was president of the American Foundrymen's association in 1901 when the first Chicago convention of that body was held. He attended meetings of the association until 1917, the session at Boston being the last at which he was present. His only son, Warren G. Jones, vice president of the company, has been general manager since his father's retirement. Mr. Jones travelled widely, having been around the world as well as having covered practically all portions of the United States. He was an outdoor man, and had hunted in practically every game section of this country.

A Turbine Driven Grinder

Pneumatic grinders find a ready application in manufacturing and repair operations where air lines have been installed for the operation of air driven tools. The grinder shown in the accompanying illustration was developed by the Turbine Air Tool Co., 710 Huron road, Cleveland. This Tool is a self contained unit embodying 18 parts. It operates at 3900 revolutions a minute and carries an abrasive wheel six inches in diameter. The turbine principle of operation permits of a wide range of speeds controlled by the throttle handle. The turbine and spindle are carefully balanced so that vibration is eliminated.

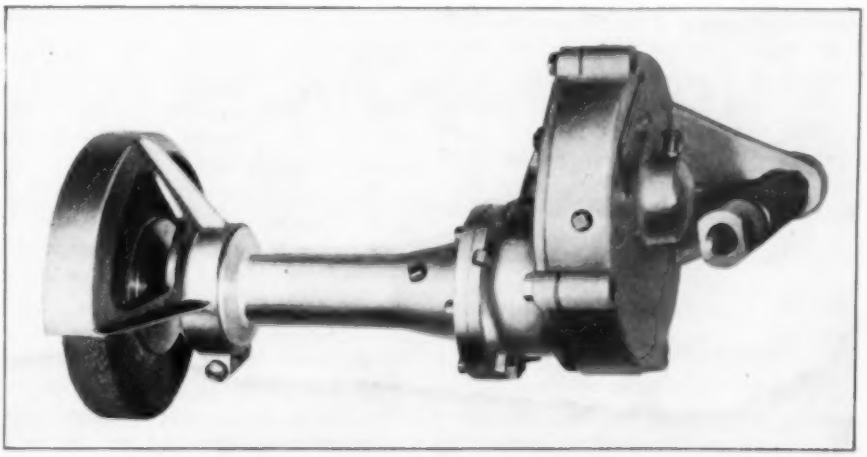
The housing of aluminum while the turbine is an aluminum alloy possessing a high tensile strength. Gears and pinions are of chrome manganese steel while ball bearings are provided to reduce friction to a minimum. The internal construction comprises a turbine motor which is a single flat disk with gears and pinions hung on ball bearings. Power is transmitted through the gears to the grinding wheel spindle. The turbine has a clearance of 1/16 inch between its outside rim and the housing so that it is not subjected to wear. Handle grips are arranged so that the operator's arm remains in a natural position, which results in a maximum output.

Cutting Cast-Iron Plates with Oxyacetylene

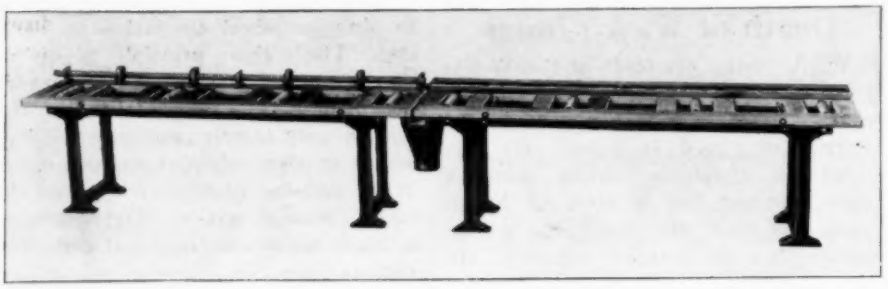
When the superintendent of a large Indiana manufacturing plant was asked if he ever had employed oxyacetylene for cutting cast iron he replied in the negative. He admitted that it might be regarded as an entertaining stunt but he knew of no place in his plant where the practice could be introduced to advantage.

Some time afterward in remodeling some of the furnaces in the power plant it was found that the cast iron floor plates for the upper deck were several inches too long and would have to be cut off. The plates had been hoisted and bolted into position at one end before it was discovered that the other ends extended over instead of resting on the center of the I-beam.

At first it was decided to drill a row of holes across the end of each plate but after 2½ days of continuous drill-



PORTABLE GRINDER OPERATED BY A TURBINE AIR MOTOR



THE STOPS ON THE GAGE RAIL CAN BE SET FOR FOUR DIFFERENT LENGTHS AT THE SAME TIME THE SCALE RAIL AND THE GAGE RAIL ARE GRADUATED IN EIGHTH INCHES FROM 0 TO 96

ing in which only two out of the four plates had been cut to size the superintendent decided to try the oxyacetylene process of cutting. Using a standard type torch the operators cut the two remaining plates in 1 hour and 45 minutes. The work was done so accurately that the ends of the finished plates were found to line up almost perfectly with the center line of the beam. The cut was approximately 1¼ inches thick and 60 inches long and the operation consumed 310 cubic feet of oxygen and 100 cubic feet of acetylene. An interesting feature in connection with the job was that although the cutting was done directly over the beam the latter was not injured.

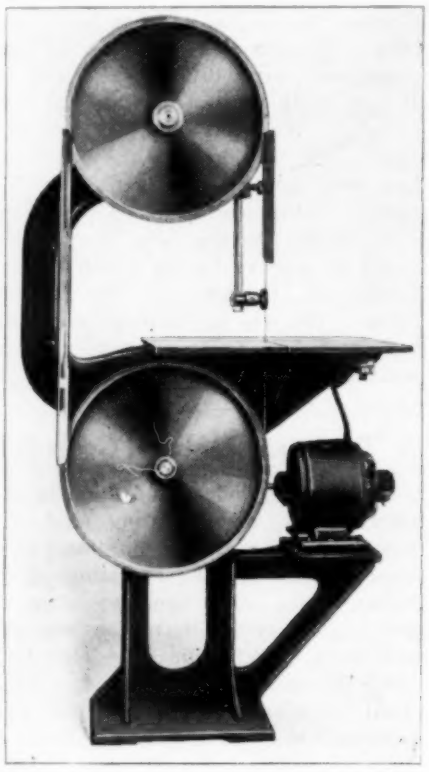
Table Equipped for Use with Swing Saw

The swing cut-off saw table shown in the accompanying illustration recently has been designed and placed on the market by the Oliver Machinery Co., Grand Rapids, Mich. The company has built swing saws for many years, but heretofore the tables have been supplied by an outside interest. The table has an over all length of 16 feet, is 19½ inches wide and 30 inches high. The top is made of kiln dried rock maple with angle iron girths and one piece cast-iron legs of rigid design.

The table is in two parts. The scale rail graduated in eighth inches from 0 to 96 is mounted on the rear of the right hand section. A cut-off gage comprising a square rod graduated in eighth inches from 0 to 96 is mounted on two rod holders on the left hand section. The rod is provided with four automatic malleable iron stops. Rollers are inserted in every other opening the full length of the table.

Metal Cutting Band Saw Requires no Care

The band saw shown in the accompanying illustration has been developed and placed on the market recently by the Clark Machine Works, Belmont, N. Y. It was built to meet the demand for a compact sprue cutting saw for use in brass foundries and shops cutting brass, bronze, aluminum or any of the softer metals which can be fed to the saw by hand. The machine is ball bearing throughout and the bearings are so designed that they require no



A SELF CONTAINED, COMPACT METAL CUTTING BAND SAW

oiling. The upper wheel bearing is packed in grease and it is claimed will run for months without any attention. All the other bearings take their lubrication from the gear box.

The saw is driven through a worm gear running in a special lubricant. The motor is controlled by a snap switch conveniently located on the under side of the table. The machine is provided with a sliding gear speed change operated by a handle on the outside of the gear box. All the gears run in an oil bath. The wheels are of web construction provided with a flange on the front side which obviates the necessity of wheel guards. The designers of the machine state that they have kept in mind the little attention usually paid to machines of this character.

Graphite Imports Lower

Imports of unmanufactured plumbago or graphite into the United States in April totaled 10,819 pounds valued at $929, compared with 137,633 pounds valued at $9142, in April, 1920. Graphite manufactured products imported in April were valued at $28,283, and in April last year at $39,275. In April exports of graphite or plumbago from the United States amounted to $54,447, against $133,276 in April, 1920. The value of exports in the ten months ended with April this year was $1,074,211, and in the ten months ended with April last year $1,934,292.

Tool Company Organized

The Master Tool Co., 203 East St. Clair Ave., Cleveland, recently has been incorporated to manufacture pneumatic tools. The company also will specialize in reclaiming all types and makes of tools of this character. The officers are: J. Nightingale, president; Charles F. Overly, vice president and general manager; and William Eckert, secretary and treasurer.

Obituary

Adolph Sorge Jr. died recently at his home in Chicago. Mr. Sorge was graduated from the Stevens Institute of Technology, Hoboken, N. J., in 1875. Shortly after leaving school he was employed by the E. W. Bliss Co., Brooklyn and had charge of their exhibit at the centennial exposition in Philadelphia in 1876. In 1893 he became general manager of the Wood-Mosaic Co., Rochester, N. Y. From Rochester he removed to Chicago and became superindent of the foundries of the Fraser-Chalmers Co., builder of mining machinery and steam engines. In 1895 he resigned to become western representative for the Harrison Safety Boiler Works, Philadelphia, subsequently the Cochrane Corp. He was one of the originators of the Technical club of Chicago and also was a member of the Engineers Clubs of Chicago and New York and the American Society of Mechanical Engineers.

Col. Charles M. Jarvis, former president of the American Hardware Corp., died May 21, aged, 65. At one time he was president of the Berlin Iron Bridge Co., and financial secretary of the Federal Adding Machine Co.

Equipment Market Remains Inactive

Scarcity of New Foundry Construction Is Noted—Crane Sales Reported in the East Largely Are for Plant Extensions — Automobile Builder Buys Molding Machines

WITH new plant construction almost at a standstill and replacement demands rapidly being supplied, the machinery and equipment requirements of foundries have reached a new low level during the past few weeks. Some signs of improvement are noted through Pennsylvania and Ohio, but most manufacturers are agreed that greater activity among foundries must precede any decided betterment in equipment sales. Automobile foundries, with few exceptions, are not buying either supplies or machinery. One Detroit passenger car manufacturer recently purchased 12 molding machines from the Berkshire Mfg. Co. Cleveland. The Standard Metals Mfg. Co., Los Angeles, Cal. contemplates the construction of a brass foundry. Walter P. Storey is president of the company.

Pittsburgh Section Continues Quiet

MANUFACTURERS of molding machines in the Pittsburgh district and producers of sand blast equipment further east report some improvement in the foundry equipment market as regards those two lines. While this is not reflected in other products such as core ovens, tumbling barrels, ladles, etc., sellers hope that this condition precedes a betterment in their lines. At present the market on foundry supplies of all kinds is dragging bottom and the past week has shown an even greater falling off in demand. A leading molding machine manufacturer in the Pittsburgh district reports sales during the past week to the Union Tool Works, Los Angeles, the Beaumont Iron Works, Beaumont, Texas, and Farrar & Trefts, Inc., Buffalo, N. Y. The first mentioned closed on two units while the latter two each bought one, the last named company taking a large rollover machine. Molding machine manufacturers are much encouraged over the fairly large number of inquiries now before them which appear to be alive and promise early business. Prospective purchasers of foundry equipment include the Union Bronze Co., Reading, Pa., recently organized by Robert P., Peter A., and A. K. Fritch, with $50,000 capital; the Lebanon Gray Iron Castings Co., Lebanon, Pa., incorporated at $30,000 by Julius H. Caplan and John Hunsicker Jr.; and the Monongahela Casting Co., Pittsburgh, which plans the erection of a one-story plant building at 505 Preble avenue. The Oberndorf Mfg. Co., 7509 Thomas boulevard, Pittsburgh, has acquired a site for proposed plant additions. Occasional sales of cranes are made, one of the latest being to the United Engineering & Foundry Co. which closed on a 15-ton Whiting crane for the Frank-Kneeland Machine Co., Pittsburgh. The Greenville Steel Car Co., Greenville, Pa., is in the market for a 10-ton crane. The Pittsburgh Screw & Bolt Co. now is in the market for two 5-ton monorail hoists. The Lockhart Iron & Steel Co. recently purchased a small 1000-pound hoist.

Replacements Govern in New York

DEMAND for foundry equipment in the East is confined principally to sundry supplies and small replacements of a routine character, and with the majority of foundries operating at not more than 50 per cent and some at well under this rate, business is far below normal. Buying of larger equipment is negligible due to the lack of new building. Rarely is a new plant project reported, and only in scattered instances are extensions being undertaken. Numerous plans have been contemplated from time to time, but actual work is slow in getting under way. Possibly the largest buyer of equipment in this district of late has been the Chapman Valve Co., Indian Orchard, Mass. This interest recently purchased two electric furnaces from the Pittsburgh Electric Furnace Corp., Pittsburgh, a 2-ton electric overhead crane from the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., and a 5-ton electric crane from another builder. These cranes are in addition to the 3-ton single I-beam crane recently reported as purchased from the Shepard company. The Vaughn Foundry Co., Norwich, Conn., bought a 2-ton handpower crane from the New Jersey Foundry & Machine Co., 90 West street, New York City. A $10,000 molding shop addition will be erected by the Southwark Foundry & Machine Co., Philadelphia, for which equipment will be purchased. The plant of the Harrisburg Foundry & Machine works, Harrisburg, Pa., under a new arrangement, will devote most of its capacity to the production of farm tractors and tractor parts, necessitating the purchase of some new equipment.

What the Foundries Are Doing

Activities of the Iron, Steel and Brass Shops

The capital stock of the American Sanitary Mfg. Co., Abingdon, Ill., has been increased from $120,000 to $240,000.

Erection of an extensive addition to its plant, 70 x 160 feet, is under way by the Plainville Castings Co., Plainville, Conn.

J. P. Sutton, 2001 Rousseau street, New Orleans, La., plans to rebuild his iron foundry, 100 x 150 feet.

The capital stock of the Petroleum Iron Works Co., Sharon, Pa., recently was increased from $10,000 to $300,000.

The Monongahela Casting Co., Pittsburgh, is reported planning the erection of a plant building at 505 Preble avenue, Pittsburgh.

The Lebanon Gray Iron Castings Co., Lebanon, Pa., has been incorporated with a capital stock of $30,000, to manufacture iron and other metal castings, by Julius H. Caplan, John Hunsicker Jr., and others.

The Pompeian Bronze Co., Brooklyn, N. Y., recently organized, has leased a building at 603-11 Dean street, which it will utilze for a plant.

The Attwood Brass Works, Grand Rapids, Mich., recently was incorporated with a capital stock of $75,000, by Hazel Attwood,

Charles E. Attwood and Charles H. Attwood.

The H. & H. Foundry Co., Tiffany boulevard, Newark, N. J., is reported planning the erection of a foundry building, to be 30 x 40 feet.

The Hold-Mor Vacuum Piston Co., Ltd., Montreal, Que., has been incorporated with a capital stock of $150,000, by R. T. Stackhouse, S. G. Dixon, R. E. Allen and others.

Capitalized at $100,000, the Trenton Chilled Die & Casting Co., Trenton, N. J., recently was incorporated by R. B. Newton, B. N. Rich and John H. Conover.

The Algoma Foundry & Machine Co., Algoma, Wis., plans the erection of an addition to its plant to be built at an estimated cost of $10,000.

Work is progressing in the erection of a 1-story pattern shop for the Dill Foundry Co., Rushville, Ind., which is being erected at an estimated cost of $40,000.

The Bierwith Pattern Works, 51 West Hancock street, Detroit, is building a 1-story factory building at Marysville, Mich., 40 x 100 feet.

The Iron King Implement Co., Madison, O., manufacturer of agricultural implements, is building a factory building, 50 x 200 feet, at an estimated cost of $30,000.

Plans are being prepared by Emil G. Perrott, Philadelphia, for the erection of a plant building for the General Smelting Co., Philadelphia.

The Union Bronze Co., Reading, Pa., has been incorporated with $50,000 capital stock, to manufacture cast metal articles, by Robert P. Fritch, Peter A. Fritch and A. K. Fritch.

Jacob A. Schneider & Co., Louisville, Ky., foundry and general machine work, recently was incorporated with a capital stock of $3000, by A. Schneider, M. M. Schneider and W. Wallace Cox.

The Tulsa Stone & Foundry Co., Sand Springs, Okla., recently was incorporated with a capital stock of $150,000, by A. C. Spitnagel, E. M. Yates, George Kinnery and others.

The Atlas Die Casting Co., Inc., Worcester, Mass., which was recently incorporated with a capital stock of $200,000, expects to start operations in a factory building at 41 Jackson street, about July 1.

The J. D. Crosby Co., Farrell street, Pawtucket, R. I., recently awarded a contract for the erection of an addition to its foundry building, 50 x 50 feet, to be built at an estimated cost of $10,000.

The Atlas Copper & Brass Mfg. Co., Chicago, has had plans prepared for the erection of an addition to its plant, one story, 50 x 125 feet, to be built at an estimated cost of $20,000.

The Barrett Tank Heater Co., Knoxville, Ill., has been incorporated with a capital stock of $100,000, by M. A. Barrett, H. A. Barrett and G. F. Hebard, to manufacture heaters and heating apparatus.

The former foundry of the Bent Iron Bed Works, Everett, Mass., which is owned by the Chelsea Iron Foundry, Chelsea, Mass., recently was damaged by fire. The loss was estimated at $25,000.

The Rockville Iron Foundry Co., Rockville, Conn., recently was incorporated with a capital stock of $50,000, by S. C. Murlless, Herbert C. Murlless and A. L. McCarthy, of Hartford, Conn.

Hodges Chain Co., Galesburg, Mich., has been incorporated to manufacture chain with a capital stock of $60,000, by Richard C. Edwards, Byron E. Shutt, Chauncey W. Hodges and others.

Capitalized at $50,000, the Troy Tool & Casting Co., Colonie, N. Y., recently was incorporated by A. and E. J. Boerder and P. B. Bird and others. The company will establish a plant for the manufacture of all kinds of castings.

The American Foundry & Mfg. Co., Frederick, Md., recently increased its capital stock to $200,000. It is said the increased stock will be used to finance plant expansions. John E. Shell Jr. is general manager of the company.

The Kansas City Foundry Co., Kansas City, Kans., manufacturer of gray iron castings, is building a foundry building, 65 x 130 feet. Owen, Payson & Carswell, 505 Interstate building, Kansas City, Mo., are architects in charge.

The Imperial Steam Appliance Co., Seattle, recently was incorporated with a capital stock of $100,000 to manufacture steam appliances, etc., by E. A. Childe, Smith building, Seattle, L. G. Spies, R. H. Webb and L. N. Vincent.

Walter E. Hindle Co., New York, recently was incorporated to engage in the foundry business with a capital stock of $5000. The incorporators are W. E. Hindle, J. Dickinson, A. C. Pardee, D. Nelson, 38 Park Row, New York, and others.

The Standard Crucible Steel Casting Co., Milwaukee, is reported planning the erection of a pattern shop, storage vault and office building at 717 Thirtieth street, Milwaukee. George F. Birkel is secretary-treasurer and general manager of the company.

The Jenkins Mfg. Co., 20 Vesey street, New York, manufacturer of valves and brass goods, has awarded a contract to Walter Kidde & Co., 90 West street, New York, for the erection of a 3-story plant addition, 50 x 80 feet, to its plant at Bloomfield, N. J.

The National Valve Co., Morristown, N. J., recently was incorporated with a capital stock of $100,000, to manufacture poppet and other type valves for steam and gas. Incorporators of the company are Edward A. Quayle Jr., James H. Samuel and Gustave F. Lowe.

Contracts for the construction of a brass foundry and machine shop, to be built at an estimated cost of $45,000, recently was let by the American Metal Products Co., 671 Kinnickinnic avenue, Milwaukee. The general contract for the erection of the building was let to the Worden-Allen Co., Milwaukee.

The Dana Machine Co., Providence, R. I., incorporated recently with a capital stock of $1,000,000, has acquired the former foundry and machine shop of the Fuller Iron Works, and will build textile, dyeing and finishing machinery, as well as calendar rolls. Officers of the company are: President, Frederick I. Dana, and treasurer, P. LeRoy Harwood.

The W. H. Phelps Co., Springfield, Mass., recently was incorporated with a capital stock of $750,000, to manufacture automobile chain and other foundry products. The company was incorporated by W. H. Phelps, Ernest W. Carman, Henry S. Wright, Fred W. Hustwick, Frank A. Rayworth and Frank H. Ellsworth, the latter two of Worcester, Mass.

Fire at the plant of the American Car & Foundry Co., Terre Haute, Ind., damaged the blacksmith and machine shops comprising about half of the entire plant. The walls of the two shops, which were housed in a section of the plant about 150 feet long, were all that was left standing. Expensive machinery and tools were ruined. The fire was the second heavy loss suffered by the plant during the last two years. In the fall of 1919 fire damaged the west section of the plant which later was rebuilt.

New Trade Publications

LADLE TRUCK—A small circular of four pages has been published by J. S. McCormick Co., Pittsburgh, in which a foundry ladle truck is described and illustrated. This truck in construction is of steel and malleable iron and is equipped with roller bearings.

PORTABLE TOOLS—The Cincinnati Electrical Tool Co., Cincinnati, recently issued a new catalog in which its complete line of portable electrical drills, grinders and buffers, is described and illustrated. This catalog contains several new types of machines, brought out recently by the company.

REFRACTORIES—A 40-page booklet in its third edition has been published by the Refractories Manufacturers' association, containing the names and addresses of all manufacturers of refractories in the country. The booklet also lists alphabetically all the various brands of fire brick and other refractories made by respective manufacturers.

LADLE HEATERS—Oil fuel ladle heaters, for heating small ladles not exceeding 20 inches in diameter, are described and illustrated in a circular recently published by the Mahr Mfg. Co., Minneapolis. These heaters are equipped with burners which operate on the vacuum principle and do not require pressure on the oil tank, according to the folder. They operate on compressed air at any pressure from 30 pounds to 120 pounds and will burn fuel oil or kerosene. Specifications and other data are given.

FACTORY BUILDINGS—A 64-page illustrated booklet has been published by Frank D. Chase, Inc., Chicago, in which various plants which the organization has designed are illustrated. The plants shown are engaged in iron and steel and metal products manufacturing. They include The Samson Tractor Co., Janesville, Wis.; The Peerless Foundry Co., Cincinnati; The Conlon Electric Washer Co., Cicero, Ill.; the Keith Railway Equipment Co., Hammond, Ind.; Gribben & Sexton Co., Chicago, and various others.

BUILDINGS—One of the most elaborate trade booklets to be issued, is that now being circulated by Stone & Webster, Inc., Boston. The booklet, which is of 48 pages, is printed on heavy coated stock and contains a number of interesting illustrations of the new buildings and equipment of the Massachusetts Institute of Technology. The illustrations include not only exterior views of the massive and imposing collegiate structures, but interior views of the various departments among them the machine tool shop, are also given. The booklet is well bound and will make a valued addition to the trade literature of the modern business library.

PULVERIZED COAL PLANTS—The Fuller-Lehigh Co., Fullerton, Pa., has published a 28-page illustrated booklet in which the use of pulverized coal as a fuel for manufacturing plants, as well as pulverized coal plants and equipment, are described and illustrated. Some interesting data, in addition to the general descriptions given in the booklet include a table showing the consumption of pulverized coal in the United States by the various industries. This table shows that in the manufacture of portland cement 6,000,000 tons are used annually; in the iron and steel industry, 3,000,000 tons; in the production of copper, 2,500,000 tons; generation of power, 1,000,000 tons; and other purposes, 1,000,000 tons, bringing the total annual consumption of pulverized coal to 13,000,000. Specifications of the various equipment are given.